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SOUTHWEST FISHERIES CENTER

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COASTAL FISHERIES RESOURCES DIVISION
La Jolla, California

SWFC Scientists Provide Training for Spain's Sardine/Anchovy Recruitment Plan

Spain's Instituto Español de Oceanografia (IEO), with a grant from the U.S.-Spain Joint Committee on Scientific and Technological Cooperation, has undertaken a 3 year program on recruitment and biomass assessment of the commercially important sardine, Sardina pilchardus. In collaboration with staff of the Southwest Fisheries Center, a program has been planned which will incorporate the new egg production method for sardine and anchovy biomass assessment pioneered by the La Jolla Laboratory, and other techniques as outlined by the Intergovernmental Oceanographic Commission for the worldwide Sardine/Anchovy Recruitment Project (SARP), under its International Recruitment Program. Alberto Gonzalez-Garcés of IEO, Vigo, and Dr. Reuben Lasker, of the SWFC, are co-principal investigators of the project in Spain which began in November 1986.

In late November and early December 1986, Dr. Jürgen Alheit, under the sponsorship of the IOC, taught a course in Vigo on the SWFC's unique biomass assessment technique, with which he has had considerable experience. Four scientists from Portugal also attended the course. Portugal has shown an interest in conducting its own SARP and in assessing the sardine biomass off Portugal. There have been discussions between Spanish and Portuguese scientists seeking to coordinate cruises and to standardize sea-going techniques to make the results from both SARP projects compatible.

The SWFC will be the host to Portuguese and Spanish scientists this year and provide specialized training in SARP techniques such as physical oceanography measurements, computerized data base management, otolith reading and planning for ichthyoplankton cruises. Dr. Paul E. Smith, expert in SARP studies from the SWFC, will visit the Instituto Nacional Investigacão das Pescas in Lisbon, and the IEO in Vigo this spring to discuss cruise planning, data handling and shipboard techniques in SARP. Accompanying Smith to Vigo will be William Flerx, Chief Oceanographic Technician, to demonstrate SARP sampling procedures aboard the R/V Cornide de Saavedra. (R. Lasker, FTS 893-7127)

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COASTAL EASTERN PACIFIC POPULATION BIOLOGY OF FISHES

Growth Rates of Northern Anchovy and Pacific Sardine during El Nino Calculated

As a part of the investigation of the sources of recruitment variability in marine fishes, Dr. John Butler, Fishery Biologist, has back-calculated the growth rates of juvenile northern anchovy during the 1983 El Nino. Growth is more variable in juveniles than in any other life stage. Juvenile growth rates affect recruitment through mortality rates by determining the duration at stage, and juvenile growth rates also affect future recruitment through adult fecundity by determining body size as the fish approach first reproduction. Since juvenile growth is affected by density-independent as well as by density-dependent factors, it is an important mechanism in determining the biomass of the adult population. To test the effects of growth variation on recruitment, Butler back-calculated growth for juveniles collected during El Nino when food may have been limiting.

Juvenile anchovy collected in the fall of the 1983 El Niño were smaller than in the previous years. Analysis of covariance (Figure 1) indicated that the small size was caused by reduced growth rather than by recruitment from spawning late in the season. Since zooplankton volumes in 1983 were below the

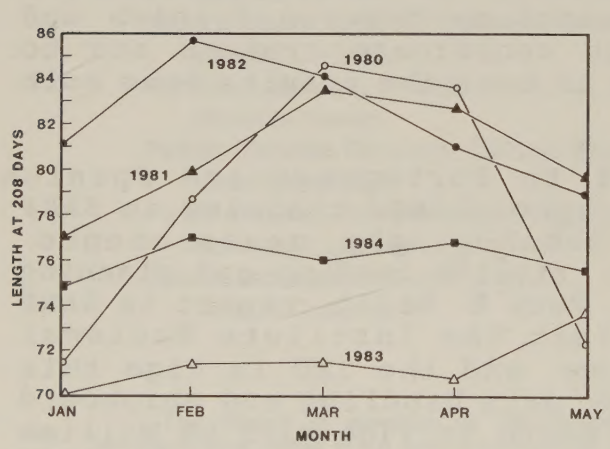


Figure 1. Seasonally adjusted size at age of anchovy spawned in the years 1980 through 1984. For each year fish are grouped by back-calculated date of hatching and length at capture is adjusted to mean age of 208 days.

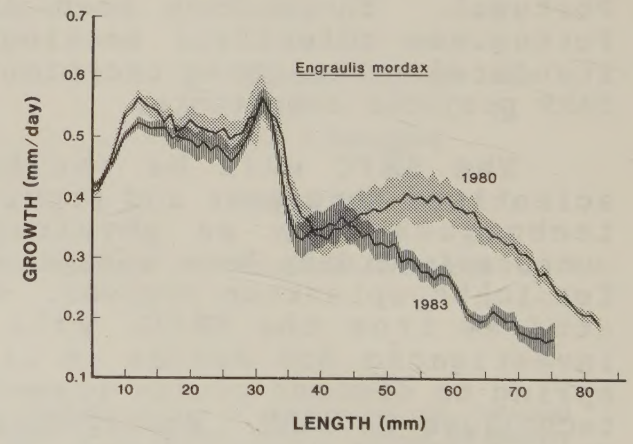


Figure 2. Mean back-calculated growth rates of anchovy spawned in March 1980 and March 1983. Growth rate of standard length in mm per day. Shaded area is 95% confidence interval.

fiduciary limits of the 30 year mean of the California Cooperative Oceanic Fisheries Investigations samples, limited food was implicated as the cause of the smaller sized recruits. Butler back-calculated growth for the March 1980 and 1983 anchovy cohorts to determine whether growth was food limited throughout the larval and juvenile stages. Comparison of the back-calculated growth of these two year classes (Figure 2) indicates that growth of anchovy was reduced at a size larger than 45 mm during the 1982-83 El Niño. On the other hand back-calculated growth rates for the first 45 mm did not vary from year to year. Thus, the hypothesis that the duration of the larval phase determines the magnitude of recruitment cannot be supported because growth in the larvae did not change even under the extreme environmental conditions produced by the El Niño of 1983. Growth of larval anchovy does not therefore appear to be food limited because there appears to be no variation between years and growth during El Niño equivalent to the maximum growth observed in the laboratory. (J. Butler, FTS 893-7149)

New National Research Council Fellow Begins Work on White Seabass

Dr. Dan Margulies has been appointed the new National Research Council Fellow at the Southwest Fisheries Center. While at the Center, he plans to study the predator/prey dynamics between larval fishes and their fish predators. Specifically, he will study the size-specific vulnerability of larval white seabass, Atractoscion nobilis, to predation by several types of fish predators. He will also examine the development of key sensory systems (mechanoreception, visual acuity) in white seabass larvae and relate the ontogeny of these sensory systems to changes in vulnerability to fish predators. Since predation seems to play a major role in early survivorship and establishment of year-class strength of marine fishes, Margulies hopes his research will provide new insights into larval fish/predator dynamics.

Margulies received his Ph.D. in 1986 from the University of Maryland where he studied fish ecology and larval fish biology at the Chesapeake Biological Laboratory in Solomons, Maryland. His doctoral research was on the early life history of the white perch, Morone americana, a member of the temperate bass family Percichthyidae. (D. Margulies, FTS 893-7140)

COASTAL EASTERN PACIFIC FISHERIES ENVIRONMENTAL INVESTIGATIONS

Satellite Remote Sensing Used to Improve Salmon Fisheries

Satellite remote sensing is an important tool used in numerous fisheries research studies at the Southwest Fisheries Center. One of the studies is yielding results that could significantly improve the salmon fisheries off the Pacific Northwest. In this study, Oceanographer R. Michael Laurs of the SWFC and William G. Pearcy of Oregon State University are evaluating the feasibility of using satellite measurements of ocean temperature and color to determine the optimal time to release salmon smolts from Columbia River hatcheries to correspond with ocean environmental conditions favorable for their survival and improve their recruitment to fisheries.

Hatchery-produced salmon contribute most of the fish that are harvested by commercial and recreational fishermen off Oregon and much of Washington. The percentage of released fish that are caught is very low, however, amounting to only about 2% for Columbia River hatcheries. About 98% of salmon that are released by the Columbia River hatcheries die. A major part of the mortality is believed to occur in the ocean soon after the young fish arrive after they are released from the hatcheries.

Laurs and Pearcy are testing the hypothesis that the survival of young salmon released from Columbia River hatcheries is related to variations in characteristics of the Columbia River plume in the ocean off the Pacific Northwest and coastal upwelling. The goal of the research is to ascertain if satellite imagery can be used to determine when ocean conditions are favorable for young salmon so that the release of the smolts from hatcheries can be timed for optimal survival. Even modest increases in survival could result in substantial increases in salmon available for harvest and have significant, measurable economic benefits.

A considerable amount of satellite and fishery data collected from 1979 to 1985 are being used in the study including (1) the numbers of smolts released from Columbia River hatcheries, (2) numbers of hatchery-released fish that were caught by commercial and recreational fishermen, and other fishery statistics, (3) information on Columbia River flow, (4) spatial and temporal

variations of the Columbia River plume, (5) indices of coastal upwelling, (6) coastal wind observations, and (7) data collected on juvenile salmon research cruises conducted by Oregon State University from 1981 to 1985. Ocean color measurements made by the Coastal Zone Color Scanner aboard the NIMBUS-7 satellite and ocean surface temperature measurements made by AVHRR sensors aboard polar-orbiting NOAA satellites are being used to determine variations in the Columbia River plume and coastal upwelling. The numbers of young salmon released from hatcheries have been extracted from individual hatchery records. The survival rates of fish that were released from the hatcheries is being estimated from information derived from catches of fish that were tagged with coded wire tags at the time of release. Additional fishery statistical information has been obtained from State fishery agencies records.

Based on the results of juvenile salmon cruises conducted by scientists at Oregon State University and other data, it appears that juvenile salmon in the ocean have a propensity to migrate to the north. However, most of the Columbia River smolts, which are about 180-200 mm at the time of release from the hatcheries, appear to be swept south when they first enter the ocean until they reach a size larger than about 300 mm. After they are larger than 300 mm, they are presumably able to swim against the southerly drift of the ocean circulation and then begin moving to the north. This suggests that the most critical time for the survival of the smolts after they enter the ocean is during the period when they are swept to the south. If there are inadequate feeding conditions for the smolts in the waters to the south where they are swept, they starve and die. If conditions are good, more smolts flourish and survival is enhanced.

Preliminary analyses of the satellite and fishery data appear to substantiate this hypothesis and suggest that the study will demonstrate that satellite data can provide information necessary to time the release of salmon smolts from Columbia River hatcheries to correspond with conditions suitable for their survival and thereby increase recruitment for harvesting.

Laurs has recently received a grant from NASA for satellite/fisheries studies. Part of these funds will be used to complete the salmon/satellite study and to prepare a manuscript of the results for publication. The remainder of the funds will be used to complete a case study involving the use of SEASAT satellite Scatterometer wind stress measurements to define locations of oceanic convergence and divergence which are believed to be important in determining availability of albacore to the U. S. fishery off the coast of North America. (M. Laurs, FTS 893-7086)

COMMERCIAL AND RECREATIONAL FISHERIES RESEARCH FOR MANAGEMENT

Sensitivities of VPA Studied

Drs. Michael Prager and Alec MacCall, Fishery Biologists, have completed a study of the sensitivities of virtual population analysis (VPA) as applied to the Pacific mackerel, Scomber japonicus. They derived dimensionless coefficients (similar to the "elasticities" of economists), which describe the sensitivities of historical VPA biomass estimates to changes in their components. Such coefficients express the expected percentage change in the VPA estimate that would result from a 1% change in an input, and thus reveal the importance of errors in the inputs in an easily interpreted way. They could be used, for example, to estimate the likely error in a past year when the data were thought to be in error.

The highest sensitivities are to estimated natural mortality (M) and to reported total catch in the year of the estimate. Figure 3 is a time plot of sensitivity to the total catch in the year of the estimate, and demonstrates that the sensitivity can vary widely from year to year. Figure 4 is a scattergram of the same sensitivities plotted against a smoothed measure of fishing mortality (F), and shows that sensitivity to total catch is high when the fishing intensity is high.

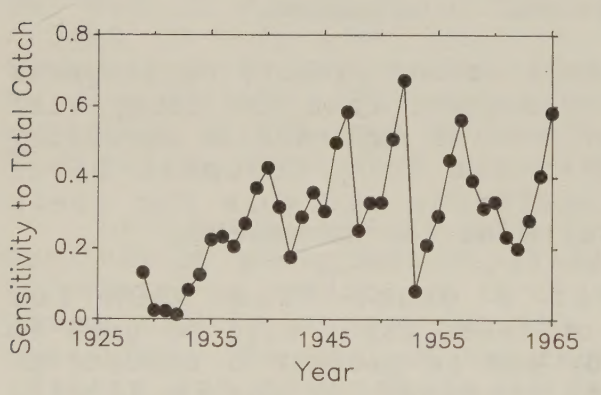


Figure 3. Sensitivity of biomass estimates to total catch in the year of the estimate.

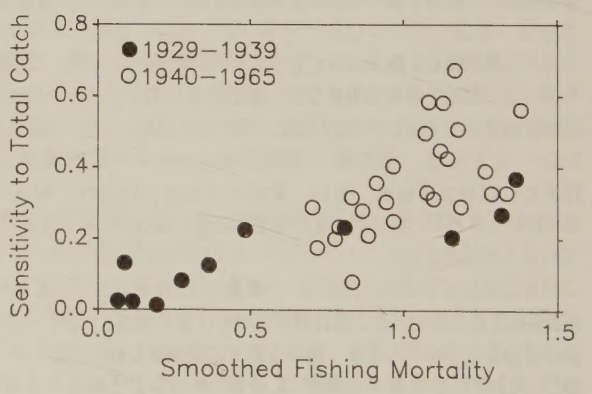


Figure 4. Relationship of fishing mortality (F) to the sensitivity of VPA biomass estimates to total catch in the year of the estimate. The smoothed F values on the x axis are arithmetic means of F in the year of the estimate and in the next 3 years.

Prager and MacCall have completed a manuscript that combines the sensitivity work with their previous work in estimating variances of historical VPA biomass estimates. The paper has been submitted to the Canadian Journal of Fisheries and Aquatic Sciences for consideration for publication (M. Prager, FTS 893-7124)

Interim Report on Contaminant Inputs Submitted by Contractor

As part of the ongoing Effects of Contaminants Study, a subcontractor is compiling existing and reconstructed data on contaminant inputs to the Southern California Bight. The subcontractor, Martin Marietta Environmental Systems, has submitted an interim report containing over 200 data series. The data included, usually by county, are records of dredging volume, kelp harvest, land use by category, human population, solid waste disposal volume, and employment by industry.

The data are being analyzed by Fishery Biologists Michael Prager and Alec MacCall, and will be used to create population dynamics models including contaminant effects. A final data report is expected from Martin Marietta in August 1987; after the report has been accepted, the data will be made available to the scientific community. (M. Prager, FTS 893-7124)

Fishery Economists Meet in La Jolla

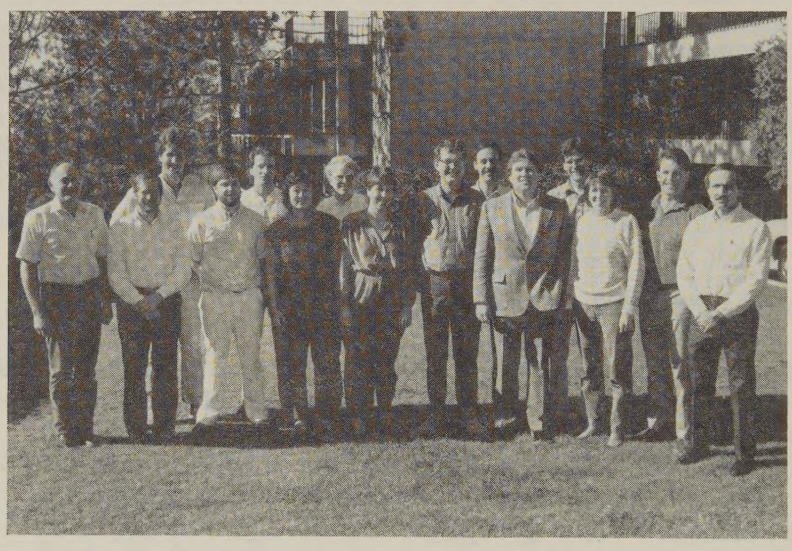
Dr. Daniel Huppert, Industry Economist, hosted a 2-day meeting of economists from the National Marine Fisheries Service and the Regional Fishery Management Council at La Jolla on February 4 to 5. This was the first time that NMFS and Council economists from Alaska have been included in the periodic SWFC/SWR meetings. The purpose of the meeting was to provide an informal forum for presentations and discussion of current research, and to encourage cooperative plans for future economics work. The presence of economists from Alaska enhanced the group's emphasis on the topics of U.S. fishery trade policy and incidental catch regulations in Alaskan groundfish trawl fisheries.

Under the topic "Data collection and processing activities," Huppert and Korson spoke on the research data base of the Pacific Fisheries Information Network; Korson discussed the use of logbook data for economic analysis; Silverthorne and Squires talked about commercial vessel cost and earnings; and Thomson presented information on recreational surveys.

On marine resource management issues, Terry discussed incidental catch regulation in Alaska groundfish; Quierollo and Rogness, international trade in groundfish; Pooley, Hawaiian fisheries management; and Huppert, limited access issues.

Explaining their special research projects, Thomson discussed recreational economics from the San Francisco Bay area; Herrick, switching behavior between trawl fishing modes; Hanna, trawl vessel discards and skipper attitudes toward risk; Squires, productivity indices for commercial fishing fleets; and Carlson, location choice model for Pacific albacore trolling. The last session was on groundfish economics research plan.

One outcome of the discussions was a renewed emphasis on building a solid base of economics data for industry monitoring and analysis. The first action based upon this will be an effort to extend the existing trawl cost data file into a more broadly-based information base. This will involve developing standard formats and procedures for cost information, collation of existing data files for albacore trollers, tropical tuna seiners, and other miscellaneous Pacific coast vessels at La Jolla. (D. Huppert FTS 893-7114)



(From left to right) Edward Ueber, Tiburon Laboratory; Daniel Huppert La Jolla Laboratory; Samuel Pooley, Honolulu Laboratory; Kevin Carlson, La Jolla Laboratory; Ronald Rogness, North Pacific Fishery Management Council; Cynthia Thomson, La Jolla Laboratory; Joseph Terry, Northwest and Alaska Fisheries Center; Dorothy Lowman, Pacific Fishery Management Council; Wesley Silverthorne, Southwest Region; Charles Korson, Southwest Region; Lewis Quierollo, Alaska Region; Dale Squires, La Jolla Laboratory; Susan Hanna, Oregon State University; Samuel Herrick, La Jolla Laboratory; and Richard Marasco, Northwest and Alaska Fisheries Center.

Further Progress on BASES Reported

Cynthia Thomson, Industry Economist, continues her work on the Bay Area Sportfish Economic Study (BASES), which will determine the net economic value of sportfishing in the San Francisco Bay and Ocean area.

Survey results indicate that approximately 473,000 saltwater recreational anglers reside in the 19 central and northern California coastal counties. The total number of trips made by these individuals in the San Francisco Bay and ocean area varies over the year, due to seasonal variations in participation rates and in the average number of trips made by those participating. The following table describes the total number of trips made in each 2-month interval over the period July 1985-June 1986.

Time interval	Total # trips (thousands)
Jul-Aug 85	445
Sep-Oct 85	447
Nov-Dec 85	342
Jan-Feb 86	284
Mar-Apr 86	436
May-Jun 86	564
TOTAL	2,518

A minority (30%) of the angling population owns a boat. However, boatowners on average make twice as many mostly boat-based trips over the course of the year than non-boatowners. Boat-based modes are also popular with non-boatowners, largely because the more popular target species in the Bay area tend to be more accessible from boat than from shore. The results of the following table show the extent to which the distribution of trips is weighted toward boat modes.

	Fishing mode				
Time Interval	Beach	Pier	Party	Private	Total
Jul-Aug 85	.21	.06	.10	.64	1.00
Sep-Oct 85	.24	.09	.14	.52	1.00
Nov-Dec 85	.26	.11	.14	.49	1.00
Jan-Feb 86	.20	.26	.11	.14	1.00
Mar-Apr 86	.27	.15	.12	.46	1.00
May-Jun 86	.14	.08	.11	.67	1.00

Approximately 60% of the shore trips and 90% of the boat trips are made with a particular target species in mind. For shore trips, striped bass is the most frequently mentioned target. For boat trips, salmon, rockfish and striped bass (in that order) are the most popular target species. (C. Thomson, FTS 893-7115)

Trawl Fleet Productivity Indicies Improved

Dr. Dale Squires, Industry Economist, modified the trawl fleet productivity index to account for changes in fish abundance. As explained in the July-August 1986 Report of Activities, the measurement of productivity change determines how much of the change in volume of output (fish harvests) is due to changes in level of input (fishing vessels, fuel, labor hours, etc.) and how much is due to changes in productivity. Thus productivity represents the effectiveness of inputs used in producing output. The increase or decrease in harvest that is not attributable to changes in levels of measurable inputs is labeled the productivity change.

The current research task was to determine what portion of the productivity changes was attributable to fish population changes. Squires obtained extensive information on groundfish and pink shrimp populations from Pacific Fishery Management Council documents and from individual researchers (e.g. W. Lenarz, Tiburon Laboratory). These abundance estimates are frequently viewed as rough indicators rather than as precise measurements. To incorporate them into the productivity framework required specifying the relationship between population abundance and trawl harvest rates.

Changes in population abundance may not directly affect productivity measures. As population abundance decreases, any given bundle of economic inputs catches an increasing proportion of the residual resource stock. Thus the "catchability" of the resource stock is not directly related to the population abundance and must be adjusted accordingly. (Alex MacCall, Fishery Biologist, provided valuable assistance in this portion.) Traditionally, the relationship between catch (C), population abundance or biomass (B), the aggregate input bundle or "effort" (f), and catchability (q) has been specified: $C/f = qB$; that is, the catch per unit effort is some constant proportion of the biomass. Catchability might instead nonlinearly decline (increase) with increases (decreases) in biomass, so that the catchability coefficient q becomes a general power function. In this study, because estimates of q were not available for each species, the estimated biomass for each species is raised to a power ranging from 0.5 to 0.9. The general catch per unit effort can then be specified as: $C/f = B^a$.

The composite measure of catchability-corrected biomass is formed from the catchability-corrected biomass estimate of each individual species. This relationship can be written as: $B^a =$

$_i d_i B_i^{a_i}$, where $B_i^{a_i}$ is the catchability-corrected biomass for each species i and d_i is a weighting factor. Weights d_i were selected to reflect the economic importance of each species i. For example, the economic importance of pink shrimp is substantially greater than its proportion of total biomass, which should be reflected by any weight d_i selected. Conversely, Pacific hake makes up a large fraction of the total biomass, but its overall economic importance is relatively small. The proportion or share of total revenue for each species i was used as weights d_i to reflect the economic importance of each species. Estimates of changes in population abundance (sometimes a bit rough) were available for the following species: widow, bocaccio, chilipepper, and yellowtail rockfish, English sole, pink shrimp, sablefish, Pacific hake, and Pacific ocean perch. These individual species were linearly aggregated to form: flatfish, rockfish, sablefish, whiting, pink shrimp, and miscellaneous groundfish. All flatfish are assumed to have annual proportional biomass changes at the same rate as English sole. Miscellaneous groundfish are assumed to be stable in biomass, an assumption which has minimal impact upon the composite biomass index because its revenue share is always less than 0.005 (.5%). Different catchability coefficients were assigned according to the different characteristics among species. This allows the proportional changes in aggregate catchability-corrected biomass to be most affected by the more variable and economically important fish populations.

The effects of allowing for changes in catchability-corrected population abundance are demonstrated in Table 1. Column (1) represents the annual growth in multifactor productivity over the time period 1981-1985 for the Pacific trawl fleet when changes in population abundance have not been disentangled from the productivity measure. This column corresponds to the productivity index reported in the July-August Report of Activities. Column (2) represents the proportional change in the index for catchability-corrected overall population abundance or biomass. Column (3) is the annual growth in productivity when the proportional change in population abundance has been factored out of the productivity measure but when variations in catchability have not been incorporated. Column (4) represents the annual multifactor productivity growth when changes in the catchability-corrected biomass have been disentangled from the productivity measure.

The effects of changes in population abundance upon measures of productivity can be considerable as a comparison of columns (1) and (4) indicate. Mean productivity growth, indicated in column (4), has been at a healthy 7% per annum but is very unstable. The high growth rate corresponds to the rapid technological innovation in vessel electronics and multiple net reels occurring during this time period and the economic pressures for rapid adoption of relatively inexpensive innovations in a common property resource with free-entry competition. The unstable productivity growth may reflect the ability of fish vessels to rapidly enter and exit an industry due

to vessel mobility and gear switching, the ability to make large changes in fishing time or the rate at which they utilize their capital stock, and the relatively sharp swings in biomass. Comparing the results in columns (3) and (4) provides the expected result that correcting the biomass for catchability reduces the impact of changes in the biomass. (D. Squires, FTS 893-7113)

Table 1. Productivity growth rates in the Pacific trawl fleet.

Year	(1) TFP plus biomass growth	(2) Catchability-corrected biomass growth	(3) TFP growth w/out biomass & no catchability	(4) TFP growth w/out biomass & catchability
1982	-0.14	-0.14	0.06	-0.00012
1983	-0.09	-0.15	0.07	0.06
1984	0.22	-0.11	0.38	0.33
1985	0.09	0.19	-0.16	-0.10
Mean	0.02	-0.05	0.09	0.07

Economic Performance of the U.S. Tropical Tuna Fleet Assessed

Changes in cannery deliveries, canned tuna production, prices, value, and consumption are useful indicators of conditions within the U.S. tuna industry. These measures, however, form an incomplete picture for assessing the economic performance of the industry because economic performance is also affected by the costs of producing output (tuna products). Indicators that reflect changes in industry output and output prices over time relative to corresponding changes in input usage and input costs would provide a more complete picture of economic performance. To accomplish this, Industry Economist Samuel Herrick has constructed a set of indices that account for changes in cannery deliveries, ex-vessel prices, inputs consumed, and input prices to examine relative changes in the economic performance of the U.S. tropical tuna purse seine fleet over the period 1979 to 1985. He traced the fleet's economic performance over the period using a composite index which is derived from an aggregate output price index, an aggregate input price index, and a total factor productivity index.

The aggregate output price index (OPI) is a weighted average of ex-vessel price indices for skipjack and yellowfin tuna over the 1979-1985 period (1979 serves as the base year, t=0, in the construction of all indices). The weights are the relative contributions of skipjack and yellowfin revenues to total ex-vessel revenue. Ex-vessel prices for skipjack and yellowfin tuna were obtained by dividing the total annual dollar value of cannery receipts for each species by total annual cannery receipts. The aggregate output price index is shown in Figure 5.

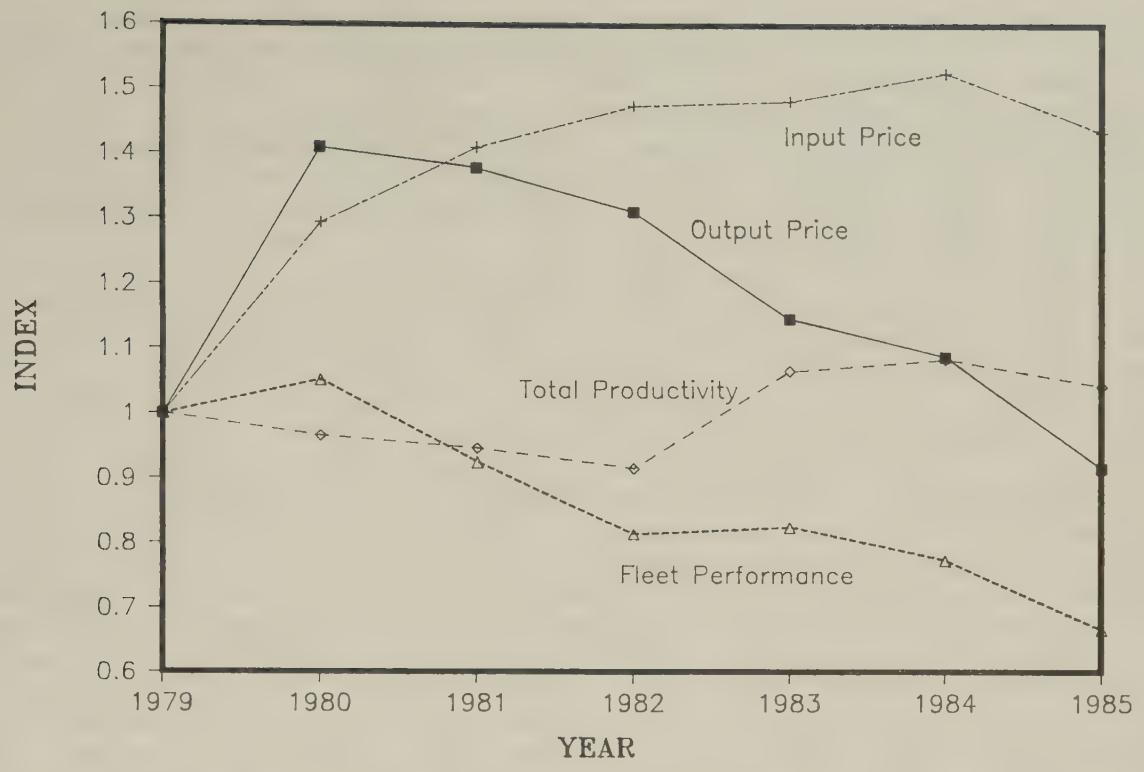


Figure 5. Economic indices for the U.S. tropical purse seine fleet, 1979-85.

The aggregate input price index (IPI) is a weighted average of price indices for major categories of factors used in owning and operating a purse seine vessel in the U.S. tropical tuna fishery. In this case, the inputs considered are labor, capital, fuel, and other intermediate inputs. Unit prices for these inputs, over the 1979-85 period, were estimated based on purse seine expenditure data reported by the U.S. International Trade Commission, data from the Inter-American Tropical Tuna Commission on the number of days the U.S. purse seine fleet was absent from port, and annual average fuel prices from the American Tuna Boat Association. The weights used in calculating the aggregate input price index are the expenditures on each input category relative to the total expenditures on inputs. The aggregate input price index is shown in Figure 5.

Changes in factor productivity, output per unit input, are accounted for through a total factor productivity index (TFPI) which is simply the ratio of an aggregate output index to an aggregate input index. Outputs used to construct the aggregate output index consist of the annual volumes of domestically-caught skipjack and yellowfin tuna delivered to U.S. canneries over the 1979-1983 period. Capital, labor, fuel, and other intermediate inputs make up the factors used to calculate the aggregate input index. The number of purse seine vessels comprising the U.S. fleet in each of the years 1979 to 1983 is used as a measure of capital stock. Aggregate labor usage is measured in crew days absent as described above. An estimate of annual fleet fuel consumption is obtained by dividing annual fuel expenditure per

vessel by average fuel prices. Fuel consumption per vessel is then multiplied by the number of vessels in the fleet to get total fuel consumption. The quantity of other intermediate inputs used annually is approximated by deflating the nominal expenditure on this category of inputs by the producer price index for industrial commodities to obtain relative use in constant, 1967 dollars. The total factor productivity index is displayed in Figure 5.

By combining the aggregate output price index, the aggregate input price index, and the total factor productivity index, a composite fleet performance index (FPI) can be written as:

$$FPI_t = OPI_t \times TFPI_t / IPI_t$$

where the terms to the right of the equal sign are those indices defined above. The FPI is an expression of the economic performance of the fleet in year "t" relative to the base year. Because the FPI is an aggregation of ratios of output prices, input prices, cannery deliveries, and input usage, it reflects the effect of a change in any of these factors. Any increase in the aggregate output price index or the total factor productivity index, or both, relative to the aggregate input price index, will register an improvement in fleet economic performance. On the other hand, the FPI will decline if input prices relative to a decrease in output prices, vessel productivity, or both, increase. The FPI shown in Figure 5 denotes the collective effect of changes in revenues, costs, and fleet productivity on fleet performance over the 1979-1983 period.

Based on projections using the purse seine cost-earnings data from the 1986 International Trade Commission investigation, Herrick found that the U.S. fleet experienced a net accounting loss in 1979, which is the base year used in calculating the fleet economic indices. Therefore, when interpreting subsequent values of the FPI, one should keep in mind that a value greater than one in year "t" does not necessarily mean that the fleet realized a profit in that year. It means that it improved its economic performance relative to the base year -- that is, the fleet could be earning a profit in "t"; the fleet could be just breaking even in year "t"; or the fleet is continuing to operate at a loss in year "t," although the loss will not be as great as in the base year. On the other hand, if the index in "t" is less than one, the fleet is performing worse than it did in the base year. Also, the indices are calculated for the fleet and therefore will not necessarily reflect the performance of an individual vessel. When a poorly performing vessel leaves the fleet, fleet performance may be enhanced due to an improvement in overall productivity. (S. Herrick, FTS 893-7111).

Mexican Anchovy Fishery Data Used in Estimating Anchovy Spawning Biomass

The Pacific Fishery Management Council sets annual quotas for northern anchovy based on the measurement of spawning biomass provided by the NMFS Southwest Fisheries Center using the Egg Production Method (EPM). The EPM is more accurate and precise than the traditional egg and larvae survey, but, although less expensive, still requires some 40+ ship days of ship time (present estimate about $8,000 a day) and several man-months of laboratory processing.

Developed in recent years at the SWFC, a statistical procedure, the Stock Synthesis model, is now being used which enables biomass estimates to be made from a variety of data sources. The SS model is calibrated to EPM measurements of spawning biomass, but also incorporates age composition data from fisheries and surveys, various opportunistic biomass indices including information obtained on California Cooperative Oceanic Fisheries Investigations (CalCOFI) egg and larva surveys, and environmental data.

Biomass indices are most useful for defining trends, and age composition data are best for estimating recruitment and short-term changes in abundance. This synthesis of information improves the understanding of historical abundance and mortality and enables biomass estimates equivalent to the EPM measurements to be made without going to sea for a period of a few years before an EPM assessment needs to be done again to calibrate the SSM.

The 1986 estimate of anchovy spawning biomass, which put the resource at 747,000 metric tons, was made from the SS model. In estimating the 1986 biomass, the model incorporated data from the Mexican anchovy fishery. Since 1977 the majority of the northern anchovy harvest has been landed at Ensenada, Baja California, Mexico. The Ensenada anchovy reduction fishery, currently landing about 100,000 metric tons per year, now dominates the total harvest. Data from this fishery are critical for accurate assessment of the anchovy resource, especially because NMFS did not conduct assessment surveys in 1986 and 1987.

Through a contract between NMFS and Living Marine Resources, Inc., anchovy fishery data for the calendar year 1986 will be supplied to NMFS. The data will include total landings, age composition, and weight at age. These data will be important in defining the level of recruitment for the 1986 anchovy year class, and in estimating the spawning biomass in 1987. (R. Methot, FTS 893-7117)

Investigations of Dover Sole and Sablefish Are Focus of Cruise

A research cruise to investigate Dover sole and sablefish was conducted on board the NOAA Ship David Starr Jordan from January 7 to February 17, 1987, along the coast of central California. The goal was to determine the feasibility of measuring the abundance of these two species through trawl catch rates, or by a modification of the egg production method which was developed for northern anchovy. The major objectives of the cruise were: to collect adult Dover sole and sablefish, and to determine their reproductive rates; to determine mean and variability of catch rates in bottom trawls; to determine the vertical distribution of Dover sole and sablefish eggs in the water column; and to determine the general level of abundance and geographic extent of their eggs.

Trawl and plankton work was conducted on Legs 1 and 3 under the direction of John Hunter and Richard Methot; on Leg 2 plankton collections with an opening-closing net (MOCNESS) was conducted under the direction of Geoffrey Moser. William Flerx was Cruise Leader for all three legs. The plankton work included a neuston sample, a standard CalCOFI bongo to a depth of 210 m, a deep bongo tow to within about 30 m of the bottom, and a non-quantitative collection made with a plankton net attached to the headrope of the 400 Eastern bottom trawl. Twenty-nine trawl/plankton stations, ranging in depth from 100-700 fathoms, were occupied on Leg 1. Twenty MOCNESS tows were made on Leg 2 at sites that seemed likely to have Dover sole and sablefish eggs. Twenty-six stations, including 20 reoccupations from Leg 1, were occupied on Leg 3.

Preliminary results indicate that Dover sole were most abundant in the 400-600 fathom depth range. These fish increased in size with increasing depth, and were actively spawning. Sablefish, on the other hand, were commonly found in the trawls at 700 fathoms. Sablefish also increased in size with increasing depth, and showed evidence of having a slightly earlier spawning season than Dover sole. Preliminary examination of the plankton samples indicates that anchovy, rockfish and hake larvae were common. To date, no Dover sole or sablefish eggs have been detected. In addition to establishing the groundwork for future assessment surveys, these trawl and plankton samples are valuable for a number of ecological studies. The deeper trawls provide a look at a rarely sampled community. Specimens for museums and for several special biological studies were returned to the laboratory. The vertically-stratified plankton samples extending from the surface to near the bottom at depths of more than 1000 m are also a unique data set that should yield much new information on the deep plankton community. (R. Methot, FTS 893-7117)

FISHERY-MARINE MAMMAL INTERACTIONS DIVISION
La Jolla, California

Methods to Estimate ETP Dolphin Mortality in 1987 Discussed

Methods to estimate the number of dolphins taken incidentally in the yellowfin tuna purse seine fishery was the topic of a meeting at the SWFC on January 15, 1987. Participants included staff from the SWFC and the Southwest Regional Office, and representatives from the Marine Mammal Commission, the Inter-American Tropical Tuna Commission, and the Porpoise Rescue Foundation. The objective of the meeting was to develop methodology that was not sensitive to changes in the percentage of vessels that carry observers (referred to as the coverage rate) and could accommodate data collected by observers on non-randomly assigned trips. The recommendations from this panel would be used by the Southwest Regional Office in developing language for the Federal Register that describes the kill monitoring methodology that will be used in 1987 and possibly thereafter.

Beginning January 1, 1987, the National Marine Fisheries Service began to place biological observers on the first complete trip of all U.S. purse seiners. Following the first trip and for the rest of the calendar year, observers will be placed at random on 50% of a vessel's trips. Additionally, NMFS intends to place observers on vessels recording unusually high dolphin mortality on the previous trip. The details of these performance standards are still being worked out, but it is clear that data collected by observers on unscheduled (non-randomly assigned) trips should be handled separately from data collected by observers on scheduled trips.

The panel noted that coverage rates will never reach 100% because of the possibility of vessels being at sea before January 1. In fact, the rate of coverage as of the meeting was 70%. This rate is likely to increase over the next few weeks as carryover trips are completed and these vessels return to sea. However, by March the coverage rate should start to decline until it reaches roughly 50% in April. Furthermore, the panel noted that if mortality rates differ between seasons, a mortality estimate that used all of the data from scheduled observers would be biased. Therefore, the panel recommended that the mortality estimate be based on the product of the average kill-per-day and the total number of vessel-days at sea by certificated vessels in the General Permit Area, with the following restrictions: 1) the average kill-per-day rate will not be stratified by time and will be based on data collected by scheduled observers only, and 2) the average kill-per-day rate will be based on data collected only by those vessels that were originally scheduled to carry observers, when the coverage rate was set at 50% for the entire year (note: this schedule has already been determined by the

Regional Office). In addition, the mortality data, collected by observers that are not to be used in estimating the average kill-per-day rate, will be added directly to the cumulative totals, but days at sea from these trips will not be included in the cumulative total of fleet days. That is, the actual number of animals observed to be killed in the fishery by observers on either unscheduled trips (performance trips) or trips that were not scheduled under the original 50% coverage rate, will be added to the estimate of total kill based on the average kill-per-day and the number of fleet days. In this way, all of the mortality data collected by scheduled or unscheduled observers is used in estimating mortality, and the estimate itself is not biased by changing the coverage rate during the year. (D. DeMaster, FTS 893-7165)

BIOLOGICAL SYSTEMS INVESTIGATIONS

Transponder Tags: A Biologist's Fantasy

Aleta Hohn, Fishery Biologist, attended a workshop on the use of radio-tagging of cetaceans to study their movements and the exploration of new, promising technologies. The workshop, which took place in Seattle from February 24 to 26, was organized by the Marine Mammal Commission and sponsored by the Minerals Management Service. The discussion focused on satellite tracking and satellite transmitter technology, techniques for long-term attachment of satellite and radio transmitters, and alternatives to satellite tracking that might answer scientists' questions regarding long-term movements of cetaceans.

The subject of a talk presented by Hohn and authored by Hohn and Andrew Dizon, Fishery Biologist, concerned one such new approach currently missing from the arsenal of telemetry devices available off-the-shelf to the biologist--a transponder tag (Figure 1). Hohn and Dizon envision a high-frequency RF (radio-frequency) device, small enough to be inserted under the skin, which, when queried, would wake up and transmit a unique identification code. Range would be line-of-sight. If the device is not queried (and assuming well-designed receivers, possibly only "listening" during daylight hours) it would last over 7 years. The query transceiver, which transmits the signal triggering the tag and in turn receives the signal carrying the identification code, would be available in three basic configurations: (1) small, portable models for point-and-shoot applications, (2) unattended models for monitoring at a fixed location, and (3) unattended models for mobile platforms. The fixed-base unattended models would be designed to continually query and record identification codes at places such as rookeries, bottlenecks of known migration routes, or remote, inhospitable sites. The mobile unattended model would be useful on fishing vessels where, in addition to monitoring tag

identification codes, geographic position would also be determined and recorded.

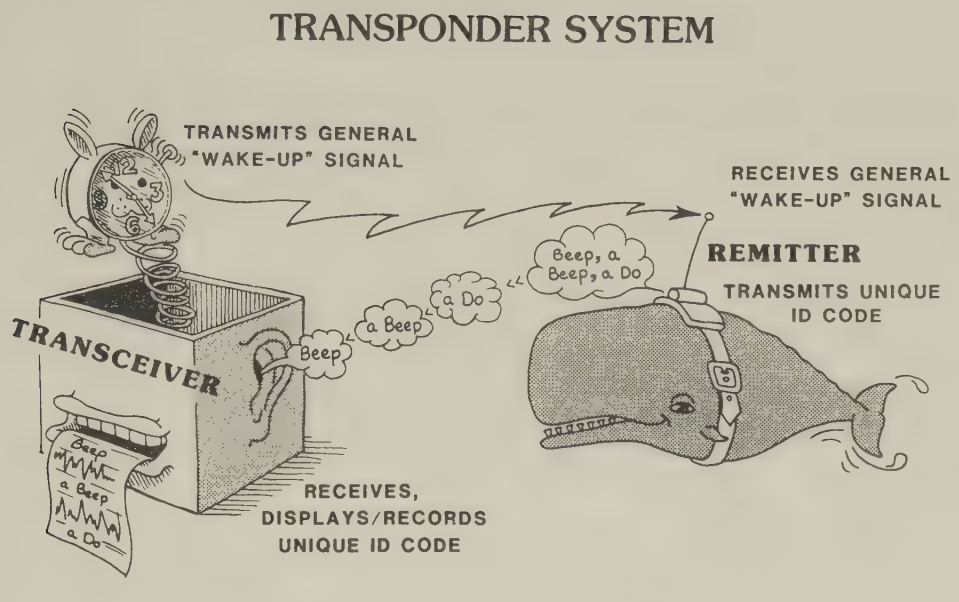


Figure 1.

Hohn and Dizon's goal at this workshop was to discuss the practicality of such devices, determine interest, and solicit potential users' requirements regarding specifications. As anticipated, interest was high in the concept of a tab that lasted through many seasons. Specialists in marine mammal medicine made a strong case for the necessity of a totally embedded tag (transponder system or otherwise). However, some concern was noted about the range of an indwelling RF tag. Engineers at the conference felt that only about 2 km were possible if the tag was deeply embedded. Hohn and Dizon are waiting for more precise calculations before proceeding in the development of such a device. (A. Dizon, FTS 893-7089)

MARINE MAMMALS ASSESSMENT INVESTIGATIONS

Paper Completed on Current Status of Harbor Porpoise

Dr. Jay Barlow, Operations Research Analyst, has recently completed work on a paper which documents the current status of harbor porpoise in central California. This small cetacean, known to biologists as Phocoena phocoena, is frequently caught in gill nets and other entangling nets that have been set for halibut. Work on assessing the status of harbor porpoise began in 1984, when preliminary estimates from the California Department of Fish and Game (CDFG) indicated that a substantial

number of porpoise may die in halibut nets each year. (Subsequently, the CDFG estimates of incidental porpoise mortality were refined and currently range from 200 to 300 porpoise per year.) With preliminary evidence of this potentially significant source of mortality in early 1984, the first priority was to determine the size of the stock which was subject to this mortality.

To determine stock size, Staff at the Southwest Fisheries Center initiated the first west-coast survey in September 1984, designed specifically to determine the abundance of harbor porpoise. Little information was available at that time to determine an optimal survey design, and thus a broad approach was chosen, including aerial, ship, and shore based observers. Operations were coordinated between NMFS, CDFG, the Oregon Department of Fish and Game, and the Washington Department of Game. This first survey was followed by three additional ship surveys in 1985-86 and another aerial survey in 1985. Results from the aerial and ship surveys indicated that harbor porpoise were more abundant in northern California, Oregon, and Washington than in central California, where gill-net fisheries were concentrated. Ships proved to be the best survey platform for abundance estimation. The estimates of current porpoise abundance from ship surveys in central California (approximately 1,850 animals) appeared insufficient to support the levels of incidental fishing mortality that were being observed.

Although the population size appeared small in central California, nothing was known about movements of harbor porpoise between northern and central California. If movement were limited and if the harbor porpoise in central California were one stock, the impact of fishery mortality would be more significant. The next research priority was therefore to determine whether west-coast harbor porpoise should be subdivided into stocks.

Stock structure was investigated by examining pollutant levels in porpoise that were found beached in California, Oregon, and Washington. Because organic pollutants, such as DDT and PCB, have very long residence times in marine mammal blubber, the pollutant level in an animal can be thought of as an integration of the pollutants ingested over the lifespan of that animal. If different levels or different types of pollutants are found in animals from different geographic locations, this indicates that individuals are not freely moving between those locations. Analyses of blubber samples were performed by Cascadia Research Collective of Olympia, Washington, with support provided by NMFS Southwest Regional Office. This study revealed that no overlap existed between the ratio of various pollutants in samples taken from California and those taken from Oregon and Washington. Furthermore, evidence was seen for differences between samples from San Francisco, Monterey Bay, and Morro Bay areas, all within central California. The pollutant study indicated that porpoise movement is relatively limited and was used to justify treating the central California population as a separate stock. Unfortunately, samples were not available for porpoise in

northern California; hence, this treatment of the data is considered provisional.

Information from the surveys of abundance and the studies of stock structure were important elements in the assessment document that was recently completed by Barlow. The other important element is the historical level of fishing mortality for harbor porpoise in central California. Accurate estimates of this mortality were available from CDFG for the fishing seasons of 1983/84, 1984/85, and 1985/86 (Figure 2). Before that time,

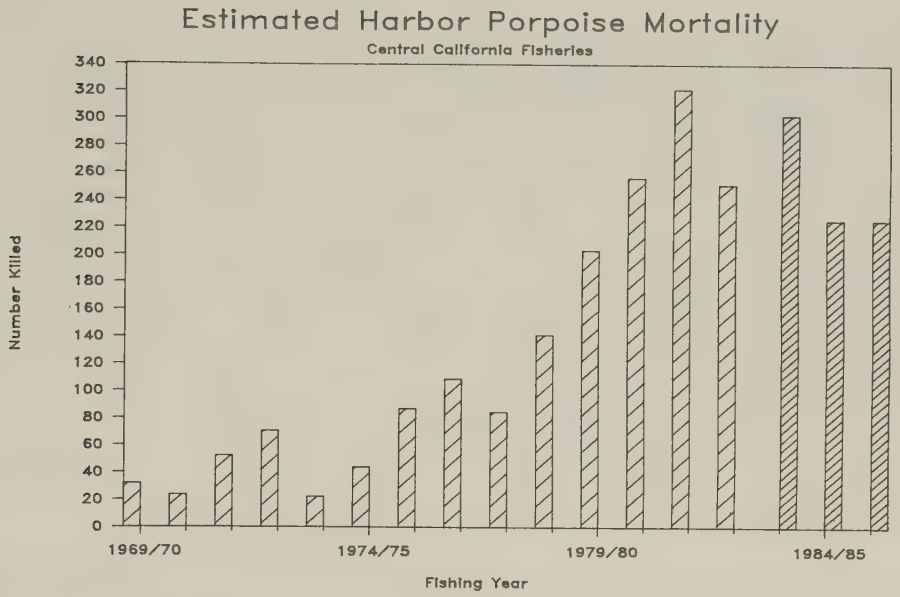


Figure 2. Estimated harbor porpoise mortality in the central California fisheries.

however, the incidental kill from gill nets was largely unmonitored. Historical CDFG records indicate, however, how many halibut landings were attributed to gill nets during the earlier years. These records can be used as an index of gill net effort. The level of incidental porpoise mortality between the 1969/70 and 1982/83 fishing years was thus calculated by assuming that the number of porpoise entangled was proportional to the level of fishing effort in the given year. The proportionality constant was estimated based on the recent years for which accurate mortality estimates are available. Resulting mortality estimates are also shown in Figure 2.

Current population estimates and historical mortality levels were used to estimate the population size in 1969. The ratio of current abundance to historical abundance (before reductions by humans) has become a critical element in the managing of marine mammal populations. The method used to estimate historical abundance (and thus the critical ratio) is known as population back-projection. This method starts with the current abundance

estimate and works backwards, accounting for both incidental fishing mortality and hypothesized rates of population growth. As might be expected, considerable uncertainty exists in estimates of mortality and population growth. Indeed, it is not possible to predict whether populations of harbor porpoise would currently grow in the absence of fishing mortality. Consequently, confidence limits on the back-projection and on the ratio of current to historical abundance are very broad. Using a population estimate of 1,854 animals in 1985, Barlow found that the ratio of current to historical abundance ranged from 0.29 to 0.81, with a central estimate of approximately 0.46.

If, as predicted by this central estimate, harbor porpoise have been reduced to 46% of their 1969 abundance, the central California population would fall into the category of depleted populations under the Marine Mammal Protection Act. In fact, porpoise populations in 1969 were probably already reduced due to gill net fishing for white seabass and halibut in the 1950s and 1960s. Although this early mortality is difficult to quantify, its effect is to add weight to an increasing body of evidence that central California populations are depleted. If this determination proves valid, harbor porpoise in central California will be given a higher degree of protection under the law. A document detailing the results presented here have been forwarded to the Southwest Regional Office to aid in developing a management plan for harbor porpoise in California. (J. Barlow, FTS 893-7178)

Status of Harbor Porpoise in California Reviewed

On January 16, 1987, a meeting to review the status of harbor porpoise (Phocoena phocoena) in California was held at the Southwest Fisheries Center. Participants included staff from the SWFC and Southwest Regional Office, and representatives of the Marine Mammal Commission and the California Department of Fish and Game. Rennie S. Holt, who chaired the meeting, introduced the objectives of the meeting, which were to provide critiques of two SWFC manuscripts: 1) abundance estimation for harbor porpoise based on ship surveys along the coast of California, Oregon, and Washington, and 2) an assessment of the status of harbor porpoise populations in central California. Both papers were authored by Operations Research Analyst Dr. Jay P. Barlow. These two manuscripts will form the basis of an assessment of the status of this species in the near future by the Southwest Regional Office.

The abundance paper was based on the results of four surveys using research vessels and teams of five observers. During these surveys, 852 porpoise groups were sighted during 6.59 km of transects. Experiments using additional observers indicated that 23% of trackline groups may be missed by a team of five observers. Porpoise density was found to vary with depth, and maximal densities occurred in water less than 75 m in depth. The size of the harbor porpoise population for California,

Washington, and Oregon was estimated to be roughly 50,000. The population estimate for central California was 1,858.

The review panel felt that Barlow's manuscript should be revised to incorporate the following points: 1) estimates of the total habitable area should not include areas where kelp occurs, 2) the variance associated with the correction factor for trackline groups that are missed should be included in the variance for the population estimate. The effect of these changes on the original estimate of population size and the confidence interval for population size will be to decrease the former by something less than 5% and increase the latter by an unknown amount.

In the assessment paper, Barlow discussed incidental fishery mortality, abundance, stock structure, population growth rates, prefishery abundance, and maximum allowable take. The status determination was dependent on the degree to which population centers of harbor porpoise were pooled and the maximum net recruitment rate. The panel recommended that Barlow consider alternative methods for calculating fishery mortality in the back-calculation projection of historical abundance. In addition, the panel recommended that Barlow investigate the possible incidental take of harbor porpoise in fisheries other than the halibut fishery, such as the current croaker fishery and the white seabass fishery of the 1950s and 1960s. A final version of the assessment document is scheduled for completion in late February 1987. (D. DeMaster, FTS 893-7165)

Military Low Altitude Reconnaissance Systems Applied to Dolphin Count

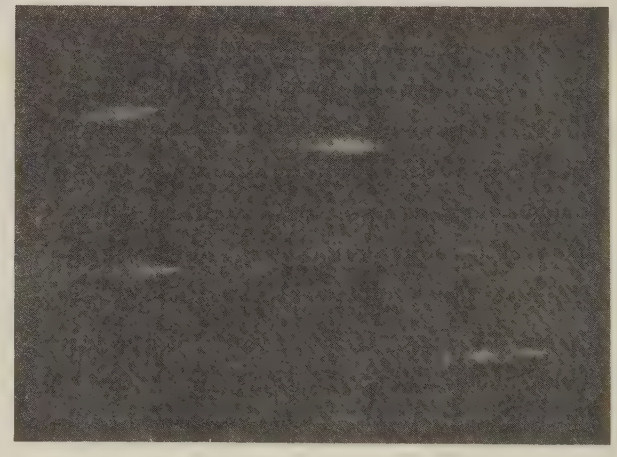
As an integral part of the 5-year program to monitor the abundance of dolphin, a research team was established under the direction of LCDR Wayne Perryman of the NOAA Corps to develop methods for estimating the number of dolphins in schools encountered by research vessels. The team also included fishery biologists Hannah Bernard and Mark Lowry and NOAA Corps Officer Morgan Lynn and Lt. Donald LeRoi of the U.S. Navy.

During the first cruise of the dolphin monitoring program conducted from July to December 1986, the scientific observers estimated school sizes by counting sections of dolphin schools and then estimating the remaining animals based on these counts. To improve the accuracy of school size estimation, a helicopter will be deployed aboard one of the research vessels during the 1987 cruise. Aerial photographs of dolphin schools will be taken from the helicopter and used for direct counts of individual school members. To identify species, determine the lengths of a large percentage of the animals photographed, and to make calf counts, the photographic images must be of sufficient quality.

When used from high altitudes over land, the fast shutters and large apertures of most modern aerial cameras can produce

images of high quality. However, from low altitudes over water where reflected light levels are relatively low, these same systems are severely limited. To solve the problem of obtaining high resolution photographs of animals that are under the water from a low altitude aerial platform, Perryman obtained a series of 5" format cameras from the U.S. Navy. These camera systems were designed to collect tactical aerial reconnaissance from high-speed, low-altitude aircraft. In addition to excellent optics, these cameras have a forward image compensation system which moves the film within the camera in such a manner that the relative movement along the line of the aircraft and the object photographed are cancelled. This feature eliminates the effect of image smear, which has been the primary factor limiting resolution in low altitude aerial photography.

To optimize the resolving power of these systems, the team has been testing various combinations of films, filters, and camera setting over standard resolution targets and on marine animals in the California Bight. The photograph in Figure 3 was taken from an altitude of 260 meters over a pair of targets deployed at Oxnard airport. The resolution targets are being used to calculate the ground-resolved distance, and the dolphin images are used to see how ground-resolved distance relates to dolphin morphology.



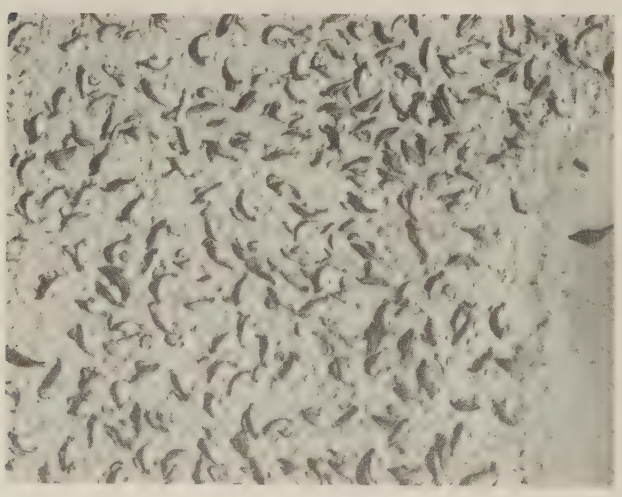


Figure 3 (top left). Resolution targets for calculating ground-resolved distance. Figure 4 (left). Elephant seals taken from 2,670 m. Figure 5 (top right). Gray whales taken from 230 m.

The smallest of the dolphin images is 85 cm long, and the test target bars (arrayed both horizontally and vertically for evaluation of directional influences on resolution begin at 38 x 7.6 cm and decrease progressively to 2.5 x 0.05 cm.

To gain experience in the use of these cameras, the team has taken vertical photographs of local pinniped rookeries and migrating gray whales over the last few months. Elephant seal males, females and pups can easily be distinguished in Figure 4 which is an enlargement of a small section of a photograph taken from an altitude of 2670 m. The gray whales in Figure 5 were photographed from an altitude of 230 m and were measured from the photograph. Their sizes ranged between 11.3 and 12.2 m (+ or - about 3%). Even from this altitude, individual differences in scars and barnacle patterns are clearly distinguishable.

After testing the 5" format cameras from the Navy, Perryman determined that the camera systems will be able to supply imageries of adequate quality to estimate dolphin school size, identify species, and determine length of the animals. (W. Perryman, FTS 893-7161)

HONOLULU LABORATORY

Honolulu, Hawaii

INSULAR RESOURCES INVESTIGATION

Vertical Distribution of Ichthyoplankton in Hawaiian Waters

The Ocean Thermal Energy Conversion (OTEC) facility proposed for construction at Kahe Point, Oahu, Hawaii, will draw unprecedented amounts of deep and shallow seawater to exploit the thermal differential to produce electrical energy. As part of a study to determine the potential impact of such a facility to early life history stages of fishes, Fishery Biologists George W. Boehlert and Bruce C. Mundy initiated a study of the vertical distribution of larval fishes around Kahe Point in September 1985.

During cruises conducted in December 1985, April 1986, and June 1986, the primary gear used to sample the ichthyoplankton was a 1 m^2 MOCNESS (multiple opening-closing net and environmental sensing system) with nine nets of 0.333 mm Nitex mesh. Sensors on the net recorded depth, temperature, conductivity, and flow in real time. Neuston samples were also taken with a modified Manta net. Three stations at 1, 5, and 15 nautical miles offshore of Kahe Point were sampled. Depths sampled were 0, 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, and 60-80 m at the shallow 1 naut. mi. station and 0, 0-20, 20-40, 40-60, 60-80, 80-100, 100-120, 120-160, and 160-200 m at the two offshore stations. Duplicate samples were taken for each location, depth stratum, and time of day (i.e., day or night).

Samples processed from the September cruise show interesting results. As might be expected, island-associated larvae were more abundant at the inshore station, generally in the upper 60 m (Figure 1). There were differences, however, between families of Gobiidae were most abundant inshore; in contrast, the Labridae (wrasses) were most abundant offshore. Oceanic fish larvae were generally abundant at all stations. Of particular interest are the larvae of Scombridae (tunas), since some of the highest known abundances of yellowfin tuna larvae have been observed off Kahe Point. Scombrid larvae were much more abundant nearshore than offshore (Figure 2). Larval scombrids were found in the upper 40 m at the 15 naut. mi. station, although at the two inshore locations almost all of the larvae were found in the upper 20 m. The catch at the inshore station was composed almost entirely of Thunnus (probably yellowfin tuna, T. albacares), whereas Auxis or Euthynnus and Katsuwonus were more abundant offshore. These data, along with those from the subsequent seasonal cruises, will be useful for allocating future sampling of tuna larvae. Distributional patterns of these and other species may shed some

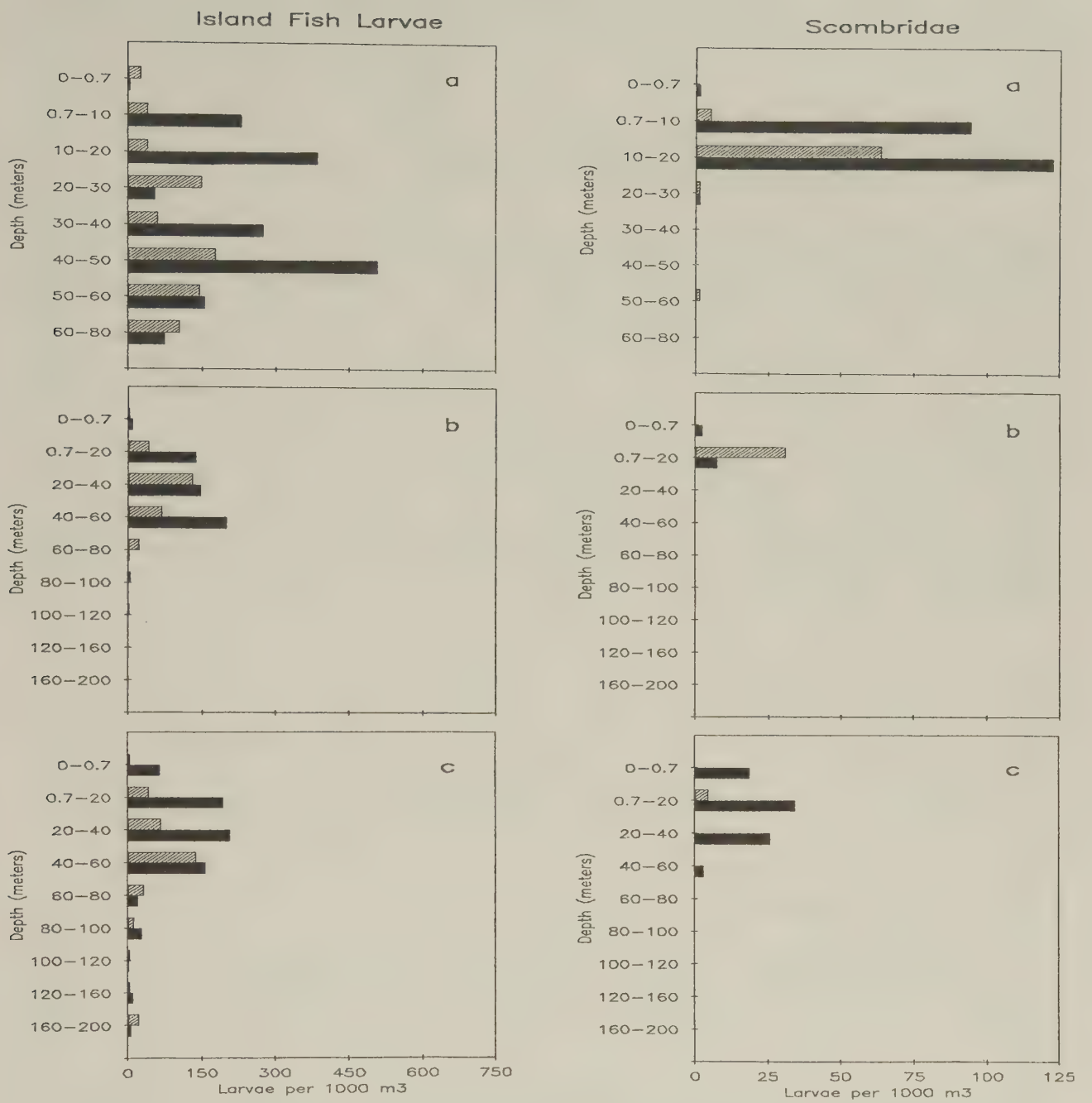


Figure 1. Densities of larvae of island associated fishes (individuals/1,000 m^3) as a function of depth at three locations. Cross-hatched (upper) bars represent daytime samples, solid bars night samples. All stations are off of Kahe Point, Oahu, at distances of 1 (A), 5 (B), and 15 (C) naut. mi. offshore. Data at depths of 0-0.7 m were taken with a neuston net, all others with a MOCNESS net. Note that the depth range in A differs from that in B and C. Figure 2. Densities of scombrid larvae (individuals/1,000 m^3) as a function of depth at three locations.

light on possible retention mechanisms for pelagic larvae around islands. Further analysis of these data as well as samples from other seasonal cruises is in progress. (G. Boehlert (808) 943-1234)

Circular Escape Vents Prove Successful for Combined Slipper and Spiny Lobster Fishery

Dr. Jeffrey J. Polovina, Leader of the Fishery Enhancement and Dynamics Task, and Research Assistant Alan R. Everson, have completed studies on the optimum shape and size of escape vents in lobster traps to permit retention of legal-size lobsters and at the same time to free undersize lobsters. The commercial lobster fishery exploits two main species, the spiny lobster, Panulirus marginatus, and the slipper lobster, Scyllarides squammosus. The landings are equally divided between the two species. The need to design an effective escape vent became a top priority when the fishery began catching slipper lobsters that were much flatter in cross section than the traditional spiny lobster. The new design, which was developed at the Honolulu Laboratory, will retain virtually all of the recommended legal size slipper lobster, and at the same time will release over 90% of sublegal slipper lobster.

Based on the reported spiny lobster sublegal capture and releases from the commercial logbooks and an estimate of spiny lobster sublegal mortality due to exposure, handling, predation, and displacement, it is estimated that the increased survival of sublegal spiny lobsters as a result of the escape vents will be worth $250,000 in increased landings of spiny lobsters per year. The benefit of escape vents to landings of slipper lobsters should be similar. (J. Polovina (808) 943-1218)

Status of the Lobster Stocks 1986 Assessed

To provide timely advice to the Western Pacific Regional Fishery Management Council (Council) for management of the lobster fishery, updates on status of stocks are necessary. Jeffrey J. Polovina, Fishery Biologist Robert B. Moffitt, and Research Assistant Raymond P. Clarke have used research and commercial data to assess the status of the slipper and spiny lobster stocks in the Northwestern Hawaiian Islands in 1986. The characteristics of the stocks have changed markedly over the past decade.

At Necker Island female spiny lobsters are first bearing eggs at a significantly smaller size than they were in 1977 (Figure 3). It is presumed that this decrease in size of the onset of sexual maturity is in response to fishing pressure. Since 1984, catch rates of sublegal spiny lobsters have declined signficantly at Necker Island, presumably due to capture and release mortality. The decline in sublegal catch rates at Necker Island corresponds to declines in legal spiny catch rates for

subsequent years. The use of escape vents in traps offers a means of reversing the decline of sublegal catch rates. In general, the spiny lobster stocks appear in good condition. The female spawning stock biomass estimate for Necker Island is 36% of the level before exploitation and the estimate for Maro Reef is 58%. If escape vents are used for this fishery, it appears that the current level of annual landings (about 900,000 lobsters) is sustainable. The slipper lobster fishery is only in its second year of heavy exploitation and current yields are not equilibrium yields. The maximum sustainable yield (MSY) for slipper lobsters is estimated at 600,000 lobsters. Thus, an MSY for the combined spiny and slipper lobster fishery is estimated at 1.5 million lobsters. The 1986 landings were 896,000 spiny and 1.2 million slipper lobsters for a combined landing of 2.1 million lobsters. (J. Polovina (808) 943-1218)

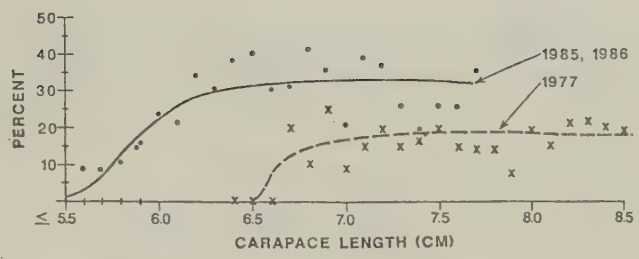


Figure 3. Percent of female spiny lobsters at Necker Island with eggs by carapace length for 1977 and combined 1985 and 1986 samples all collected in months of July and August.

FISHERY MANAGEMENT RESEARCH PROGRAM

Hawaii's Tuna Industry in the 1980s Examined

Linda L. Hudgins, East-West Center, and Samuel G. Pooley, Industry Economist, completed a paper, "Growth and contraction of domestic fisheries: Hawaii's tuna industry in the 1980s," which will appear as a chapter in a forthcoming book, Tuna Issues and Perspectives in the Pacific Islands Region, edited by David J. Doulman of the East-West Center's Pacific Islands Development Program.

Hudgins and Pooley examine the events that are leading to the restructuring of the tuna industry in Hawaii, with special emphasis on the skipjack tuna sector. They provide new estimates of various components of the Hawaii tuna fishery. The estimates indicate that the decline of the skipjack tuna fishery since the mid-1970s has reduced its contribution to total tuna landings in Hawaii substantially. As a result, the handline, longline, and troll tuna fisheries have increased in importance (Table 1 and Figure 4). The handline (ika shibi and palu ahi) tuna fisheries have grown the most rapidly, and the longline fishery is most important for exports. The recreational fishery is important for secondary market sales and for domestic consumption. The North Pacific albacore troll fishery has had variable landings in Hawaii, some of substantial magnitude.

Table 1. Hawaii tuna fishery production, mid-1980s. Estimated landings: metric tons and value

	Metric tons	$ million
Pole-and-line	1,300	2.70
Longline	370	1.70
Handline	615	2.10
Trollers (local)	410	1.10
Recreational	2,050	5.30
Distant-water albacore trollers	1,100	1.10
TOTAL TUNA	5,845	14.00

Notes:

This table represents unofficial estimates based on the most recently available data. In some cases, extrapolations are employed. Averages of several years are also employed.

Hawaii Division of Aquatic Resources figures for commercial tuna landings in 1984 were 2,745 metric tons valued at $6.5 million.

Recreational dollar values are based on commercial troll prices. This is not an accurate estimate of the complete, non-market recreational value associated with fishing for tuna.

Actual data sources are cited in the Hudgins/Pooley chapter.

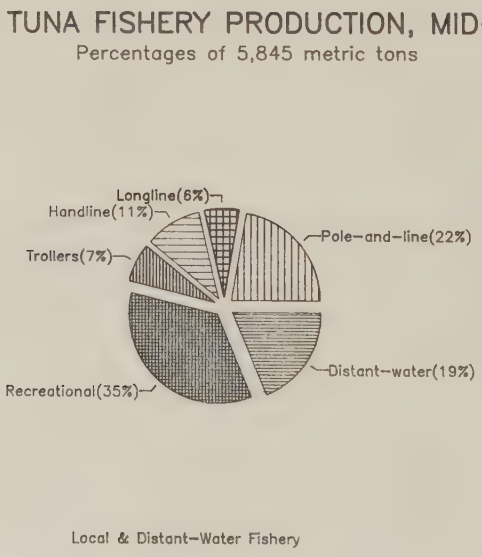


Figure 4. Estimated landings (percentages) by fishery.

Hudgins and Pooley argue that linkages to an external market (the cannery in the case of skipjack tuna) are an important factor in the scale of the fishing fleet and the development of the industry. Without a cannery or similar external market, neither the albacore troll landings nor the pole-and-line skipjack tuna fishery will be able to meet their potential. Furthermore, given the interconnections of the fresh tuna market, surpluses in one segment of the fishery will affect prices and incomes in other segments. They concluded that "the future of the tuna industry in Hawaii will depend on continuing to pursue new markets as well as fulfilling current market demands with high-quality fish." (S. Pooley (808) 943-1216)

Strategic Planning for Hawaii's Aku (Skipjack Tuna) Industry

Fishery Biologist Christofer H. Boggs and Samuel Pooley completed a document, "Strategic planning for Hawaii's aku industry" (Southwest Fisheries Center Administrative Report H-87-1). The report presents the results of a series of planning meetings in 1986 which were designed to recommend specific activities and initiatives to address the problems facing Hawaii's commercial pole-and-line skipjack tuna industry (locally known as the aku industry). The industry once supplied 20% of the local tuna cannery's pack, and industry landings amounted to 80% of all tuna landed in Hawaii. By 1986 landings had plummeted and the cannery was closed. Economic conditions for the vessel owners were considered severe.

The planning meetings drew together representatives of industry and government who participated in a structured decision-making process. The planning group recommended that the next step would be to consult formally with the aku industry as a whole. Accordingly, the report was mailed to all aku vessel owners and many dealers of fresh seafood, hand carried to all aku vessel captains, and also presented to the State's Hawaii Fisheries Coordinating Council. The planning group also recommended the creation of an industry oversight group to spearhead government activities in the fishery and recommended establishing a market research-analysis agenda and implementation plan.

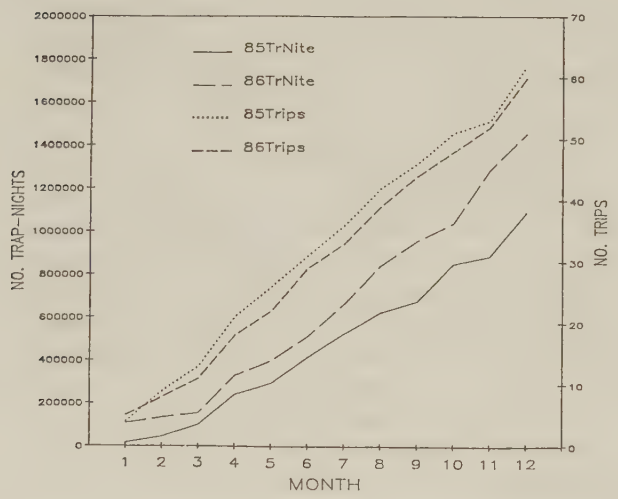
The primary goals and objectives identified by the planning group for the future of Hawaii's aku fishery community include: maintaining a viable tuna cannery operation; developing new product forms and markets; providing means of handling/processing surplus fish to stabilize the local market; meeting local market demand for aku competitively; and providing better and more realistic means of gathering and enforcing of data gathering on fish catch. (S. Pooley (808) 943-1216)

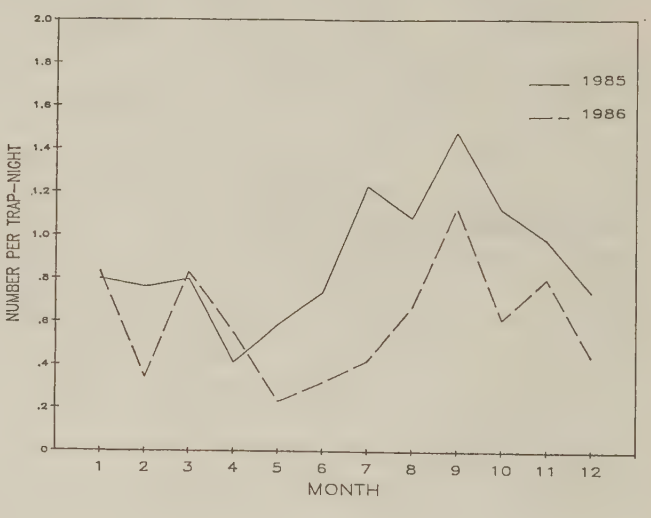
Northwestern Hawaiian Islands Lobster Fishery Remains Stable in 1986

The Northwestern Hawaiian Islands lobster fishery remained stable in 1986 following the 1985 record year. Landings and fishing effort data by month for 1986 are shown in Table 2. Spiny lobster landings showed a 9% decline in landings (number of lobsters) in 1986 compared to 1985, and there was a 4% increase in slipper lobster landings. Spiny lobsters made up 41% of lobster landings in 1986 compared to 45% in 1985.

The 16 permitted vessels took a total of 60 trips to the Northwestern Hawaiian Islands in 1986. In 1985 there were also 16 vessels which took 63 trips. Total fishing effort, measured by trap-nights, rose to 1.5 million in 1986, compared to 1 million in 1985 (Figure 5). Catch per unit effort fell for both species: catch per trap-night for legal spiny lobsters fell from 1.31 lobster in 1985 to 0.93 in 1986; slipper lobster catch rates fell from 1.09 lobster in 1985 to 0.85 in 1986 (Figures 6 and 7). These rates are not adjusted for any changes in trap design or fishing patterns.

The annual report on the fishery, including information on revenues, will be released in April 1987. (S. Pooley (808) 943-1216)





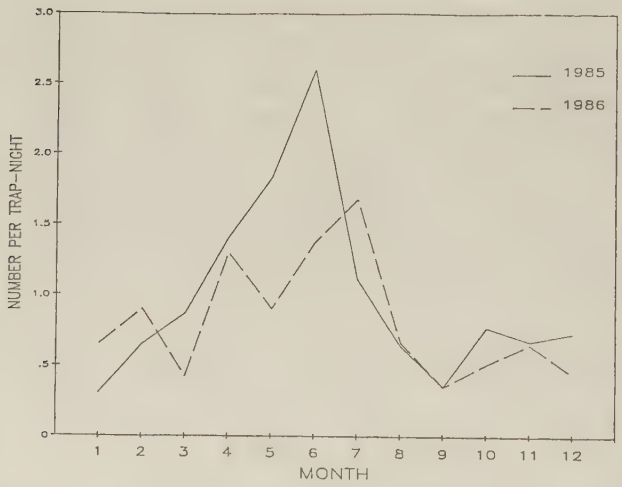


Figure 5 (top left). Fishing effort (trap-nights), 1985 and 1986. Figure 6 (top right). Spiny lobster monthly catch rates, unadjusted, 1985 and 1986. Figure 7. Slipper lobster monthly catch rates, unadjusted, 1985 and 1986.

Table 2. Estimated annual sales of spiny and slipper lobster. Ex-vessel price is in dollars per pound and ex-vessel revenue is in dollars. Weight is in terms of whole animals as is ex-vessel price. See text for source of data.

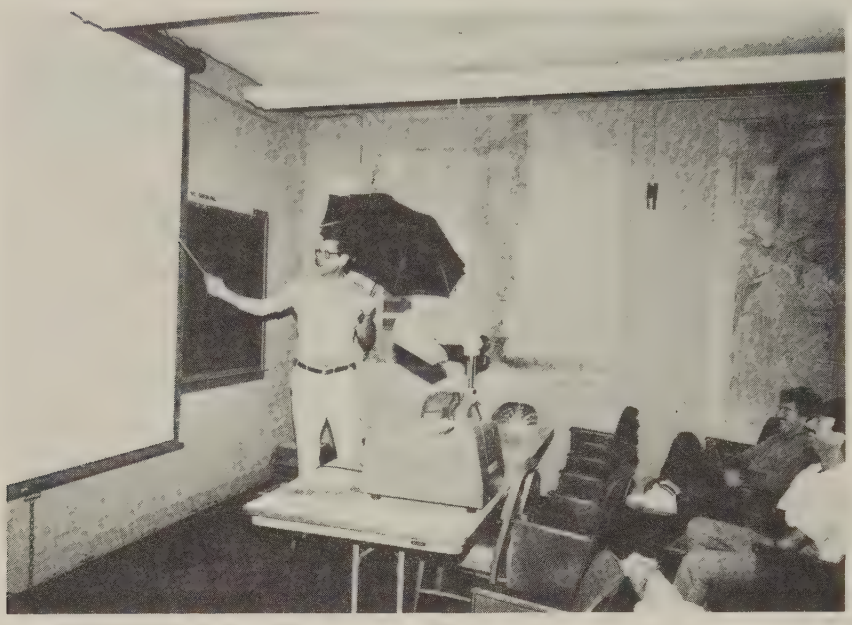
	Spiny lobster				Slipper lobster					
Year	Pounds	Metric tons	Price	Revenue	Pounds	Metric tons	Price	Revenue	No. of vessels	No. of trips
1977	72,000	30	2.90	209,000	--	--	--	--	5	14
1978	45,000	20	3.00	135,000	--	--	--	--	2	12
1979	100,000	50	3.20	320,000	--	--	--	--	2	6
1980	328,000	150	3.40	1,115,000	--	--	--	--	3	12
1981	780,000	350	3.50	2,730,000	--	--	--	--	10	25
1982	187,000	80	3.60	673,000	--	--	--	--	7	19
1983	203,000	90	2.91	591,000	--	--	--	--	4	19
1984	935,000	425	2.66	2,490,000	220,000	100	1.64	361,000	11	38
1985	1,438-00	654	2.94	4,227,000	930,000	423	1.78	1,660,000	16	62
1986*	1,146,000	521	3.23	3,701,000	1,065,000	484	2.15	2,296,000	16	60

*Preliminary estimate.

Second Volume of Fishery Statistics of the Western Pacific Distributed

The second volume of the Western Pacific Fishery Information Network (WPACFIN) report series, "Fishery statistics of the western Pacific," was completed and distributed. This series was created as the principal means of formally distributing summary fishery statistics among the Pacific islands fisheries offices. Volume II contains about 230 pages of summary tables, graphs, and explanatory text on commercial and creel survey data collected for the Territory of Guam from 1979 through 1984. Volume I, which was completed in March 1986, contained similar information for the Commonwealth of the Northern Mariana Islands (1979-84), the Territory of American Samoa (1982-84), and the State of Hawaii (1979-84). Tables of monthly and calendar year summary statistics of pounds, value, and average price per pound for each species or species group landed are provided for the commercial fisheries. Graphs of seasonality and landings trends are provided for many of the major pelagic and bottom fish species. Monthly and annual creel survey statistics include estimates of catch, effort, catch-per-unit-effort, and participation for each of the major fishing methods used on Guam, as well as estimates of species composition and pounds landed by species for the major methods of trolling and bottom fishing. These reports are used heavily as major resource documents by numerous groups working on fishery management related problems in the western Pacific. The next volume of this series will contain updates from these four island areas for 1985 and 1986 and may be available later this year. (D. Hamm (808) 943-1214)

Fisheries Research of the Rainy Northwest Pacific Described



Dr. Gary Stauffer, Director of the Resources Assessment and Conservation Engineering (RACE) Division of the Northwest and Alaska Fisheries Center presented a seminar on the research activities of RACE. Of particular interest to Honolulu Laboratory staff was the discussion of the Fisheries Oceanography Coordinated Investigations research in the Shelikov Straits, Alaska.

This was Stauffer's second visit to Hawaii from the rainy Northwest, and he was made to feel at home by the wet weather both outside and inside the Honolulu Laboratory seminar room. His presentation took longer than expected, since he continually had to move his umbrella from side to side to allow the entire audience to see his graphics (standard issue HL raingear was too small for the tall Stauffer). Further, he was unfortunately not forewarned by Honolulu Laboratory staff to be sure to use waterproof ink on his notes, resulting in difficulties in following his outline. Future seminars in this series will include "Effects of freshwater influx on nehu populations of Pearl Harbor," "Water resources of the Hawaiian Islands," and "Water content of the flesh of Mahi Mahi." (M. Dutro (808) 943-1221)

MARINE MAMMALS AND ENDANGERED SPECIES PROGRAM

Workshop Held to Address Hawaiian Monk Seal "Mobbing" Problem

William G. Gilmartin, Leader, Marine Mammals and Endangered Species Program (MMES), reports that a workshop was held in Honolulu from February 17 to 20, 1987, to address the problem of adult male attacks, or "mobbings," on adult female and other seals. The workshop was very successful in meeting its charge to develop a plan to reduce the number of deaths of female monk seals caused by aggressive adult males. Workshop participants included five members of the Hawaiian Monk Seal Recovery Team and five other scientists with expertise in animal behavior, genetics, endocrinology, and general physiology. During the first day, MMES staff gave presentations on all aspects of the research program, including all of the available background information on the "mobbing" problem. The remainder of the workshop was devoted to discussing the data presented, considering possible causes of the behavior pattern at certain islands, determining additional information needs, and drafting a plan to mitigate the problem.

There was full agreement on the need to begin research on methods for controlling the aggressive behavior of male seals, using a reversible chemical technique. In this way, up to 50% of the adult males at Laysan Island could be chemically and temporarily "removed" from the population, allowing an assessment of the effects of such "removal" on male social structure, pup production, and female survival. The proposed action calls for a 2-year development of the drug control method on captive adult male seals. During this time, additional data from field observations will be collected to help determine which seals will be controlled. Criteria were established to evaluate the success of the field trials and conditions were set which would cause this course of action to be reevaluated. (W. Gilmartin (808) 943-1239)

Occurrence of Tumors on Green Sea Turtles Increasing

An increasing number of green sea turtles, Chelonia mydas, with neoplastic tumors have been found stranded in the main Hawaiian Islands, reports Zoologist George H. Balazs. The growths, which have been identified as fibropapillomas, usually occur on the head, neck, mouth, or soft tissue at the bases of the flippers, and may impede swimming, cause blindness, or otherwise impair foraging ability, thus debilitating the animal and causing death. Although several years ago the occurrence of such tumors was only occasionally reported, in 1985 and 1986 tumors were present in 35% of all stranded turtles recovered. The cause of these tumors is uncertain. The ova of a parasitic blood fluke are usually associated with these neoplastic growths, but a cause-and-effect relationship has not been demonstrated,

and the life cycle of the parasite in the marine environment is not known. Balazs is routinely collecting blood samples from affected turtles which strand alive to determine if the condition is correlated with circulating fluke ova. Further research is needed to determine the etiology of the disease and assess possible solutions. (G. Balazs (808) 943-1240)

PELAGIC RESOURCES INVESTIGATION

South Pacific Albacore Survey Completed

The NOAA Ship Townsend Cromwell recently completed its second survey of South Pacific albacore grounds in the Southern Subtropical Convergence Zone. The survey began in Tahiti on January 16 and ended in Rarotonga on February 16, 1987. It was preceded by an exploratory cruise in January-February 1986. The surveys are part of a coordinated international program to describe the near-surface physical oceanography of the region, develop models of albacore biology required for stock assessment, and support efficient development of surface albacore fisheries in the South Pacific. One key objective is to understand relationships between the distribution and availability of albacore in near-surface waters and such factors as forage density, structure of temperature and salinity fields and bathymetry. Another is to develop predictive models of South Pacific albacore migration. Major participants in the program include staff from the SWFC Honolulu and La Jolla Laboratories, the New Zealand Ministry of Agriculture and Fisheries, the French agency ORSTOM (Tahiti and New Caledonia offices), the South Pacific Commission, and the albacore industries in the United States and New Zealand.

Chief Scientist Dr. Jerry A. Wetherall reported that the cruise was highly successful. Joining Wetherall on the Cromwell's scientific party were Biologists Christofer H. Boggs, Victor A. Honda and Shigeru Yano of the Honolulu Laboratory, Oceanographers Kenneth A. Bliss and R. Michael Laurs of the La Jolla Laboratory, and biologists Kevin Bailey of New Zealand, Ned Howard of the Cook Islands and Viliami Langi of the Kingdom of Tonga. Participation of Bailey and Howard was arranged and financed by the South Pacific Commission.

The Cromwell, under the command of Lt. Cmdr. Dale Bretschneider of the NOAA Corps, occupied 73 CTD stations to a depth of 1,000 m, primarily along N-S transects placed at long. 149°, 152°, 162°, and 165°W approximately between lat. 35° and 43°S. During daylight hours between CTD stations, 10 jig lines were trolled to monitor the density and distribution of albacore and to collect specimens for tagging and biological sampling. A continuous record of the density and distribution of upper ocean scattering organisms, including albacore forage, was collected by photographing chromoscope images. Night-light stations were

occupied to collect undamaged specimens of albacore forage, and surface neuston hauls were made to sample ichthyoplankton, including albacore eggs and early larvae, on transits through tropical and subtropical waters where albacore are known to spawn. Expendable bathythermograph probes were dropped routinely throughout the cruise, augmenting upper-ocean temperature data in a region only sparsely sampled. Systematic bottom depth records were compiled for inclusion in the South Pacific data base of the International Hydrographic Office.

The two easternmost transects of the Cromwell cut through an area being fished with phenomenal success by five U.S. albacore jig vessels, the Natalie Rose, Day Star, Bald Eagle, Jeannie and Defiance. During January, these boats caught full loads of roughly 40 to 85 tons of albacore between about long. 147° and 153°W and approximately lat. 36° to 39°S. They offloaded their first-trip catches in Papeete and returned to the grounds, joined in February by two other U.S. jig boats, the Red Baron and Madonna. Several of the boats received a fuel subsidy from Saltonstall-Kennedy funds provided to the Western Fish Boat Owner's Association. Under an agreement with the French, samples of U.S. jigboat landings in Papeete will be measured by ORSTOM technicians.

In the area where the five jig boats were working in January, excellent catches were also made by the Cromwell; as a result 426 albacore were tagged with dart tags (of the new Hall type), injected with tetracycline and released. Tagged fish ranged from 47 to 97 cm fork length; most were 60-80 cm (10-25 lb). A large number of albacore were also sampled for biological material, including otoliths and vertebrae (for estimating age and growth), gonads (for evaluating sex ratio and reproductive state), stomachs (for analysis of albacore forage and feeding habits), heads and viscera (for analysis of parasite fauna and albacore stock composition), and muscle tissue (for evaluation of fat content and proximate composition).

The Cromwell observations will be integrated with information gathered by U.S. jig boats and by cooperating government research vessels from New Zealand (the RV Kaharoa) and France (the RV Coriolis) operating in other parts of the convergence zone during February. All of the commercial boats are maintaining detailed logbooks of catch data and are tagging, injecting, and releasing albacore. Some are dropping XBT's as well. The Kaharoa is executing a CTD/trolling survey and tagging albacore in the same manner as the Cromwell along several N-S transects from long. 170°W to the dateline, and the Coriolis is doing likewise along N-S transects between long. 120° and 135°W. The extensive coverage achieved by the joint surveys and the concurrent exploration of the area by the fishing vessels will provide the first comprehensive description of near-surface oceanography in the convergence zone together with an assessment of the distribution and availability of albacore to surface trolling.

Townsend Cromwell Fisherman Kirk Paulo, Oceanographer Mike Laurs and Biologist Jerry Wetherall approach the U.S. albacore jig boat Natalie Rose on the South Pacific albacore grounds to deliver tagging equipment.

Although formal analysis of the survey observations has not yet begun, preliminary inspection of CTD data shows that a good definition of the convergence zone was achieved on all four N-S transects by the Cromwell. The two easternmost transects were through the heart of the area where the jig boats were experiencing excellent fishing in January. Here the transition between subantarctic and subtropical waters was observed between roughly lat. 37° and 38°S. As expected, this was also the region of the highest catch rates by both the Cromwell and the jig boats. During the period of good fishing in this area, seas were relatively calm and there was a well-defined mixed layer down to a thermocline beginning at 20-25 m.

Albacore stomachs were frequently full, the predominant food item was juvenile Peruvian jack mackerel, Trachurus murphyi. Chromoscope imagery, catch rate data, stomach data, and jig boat logbook observations will be studied for insights on the association of albacore with forage concentrations and structure of the near-surface waters.

In early February, when most of the jig boats were absent from the fishing grounds, the Cromwell moved westward on a zig-zag pattern through the convergence zone and executed the CTD transects along long. 162° and 165°W. Here the transition between subtropical and subantarctic waters was found at roughly the same latitudes as on the earlier transects. However, it was overlaid by a layer about 30 m thick of warm water ranging from 20.5 to 21.5°. These temperatures were 1-2° warmer than the

upper layer temperatures farther east where albacore catches had been high. Also, the mixed layer depth to the top of the thermocline was up to 30 m deeper than the mixed layer farther to the east. During this period there was an extended spell of sunny and calm weather. The warm upper layer ocean temperatures are believed to have resulted from in situ heating where high levels of solar radiation associated with the clear skies provided much heat which was not mixed with deeper waters, as is the usual case, because of the lack of winds. By the time the Cromwell completed the transect along long. 165°W brisk winds had restored the mixed layer, but few albacore were taken north of lat. 40°S. The only significant flurries of jig strikes occurred where the Cromwell passed over the Louisville Ridge, a chain of seamounts originating near the Kermadec Trench and extending southeast past the Chatham Rise. The ridge was crossed near seamounts which rose sharply to about 800 m from the surface, from a background seabed depth of roughly 5,000 m. When the data from the Cromwell are combined with observations made by the Kaharoa further west over the Chatham Rise, one objective will be to assess the influence of submarine topography on the structure and dynamics of the near-surface water and the distribution and availability of albacore.

During the Cromwell survey, transect placement and location of "albacore water" in the region was assisted greatly by sea-surface temperature imagery received from NOAA polar-orbiting satellites equipped with infrared sensors. Images were received in near real-time and enhanced using the shipboard JCV-16E Oceanographic Color Display on loan to the Honolulu Laboratory from the Japan Radio Company. (J. Wetherall (808) 943-1258)

DATA MANAGEMENT AND TECHNICAL SERVICES

Electronic Bulletin Boards Utilized

Staff of the Data Management and Technical Services have accessed two electronic bulletin boards, Uncle Sam's Federal Employees Bulletin Board and The Whopper. They are free and available to anyone having a modem and communication software with error-checking (such as XMODEM or Kermit) on their computer. Uncle Sam supports most major computers, and The Whopper files are for use on IBM PC's or compatibles. User access time is limited to 45 minutes per day on both bulletin boards. The public domain files found on bulletin boards are an alternative to costly, brand-name software. The staff has also downloaded several programs. Programs available include disk utilities (e.g., enhancements to DOS), "patches" or add-ons for commercial software such as Lotus or Wordstar, printer drivers, and tutorials for various programming languages. One of the downloaded programs, SQUEEZE (DOS format) which allows files to be compressed before being transferred, is now used regularly at the Laboratory. A second downloaded program (Federal Retirement

Benefit Project Model) will be used to calculate and compare employees' retirement benefits under the new and old retirement systems. (W. Higuchi (808) 943-1260)

PACIFIC FISHERIES ENVIRONMENTAL GROUP

Monterey, California

Eastern Boundary Current Comparative Studies
Hypothesis of Local Wind Generation of
Tropical Thermal Domes Questioned

According to Hofmann, Basalacchi, and O'Brien, writing in Science (1981, vol. 214, pp. 552-554), tropical thermal domes, such as the Costa Rica Dome, are generated largely by local Ekman pumping associated with cyclonic wind stress curl related to intertropical convergence zones. Andrew Bakun, Oceanographer, has assembled data on eastern ocean wind stress curl characteristics, and his analysis of the data has called into question the general validity of this hypothesis.

Bakun analyzed the characteristic seasonality of wind stress curl in the localities of the Guinea Dome, in the eastern tropical north Atlantic, and the Angola Dome, in the eastern tropical south Atlantic (Figure 1). Cyclonic wind stress curl (i.e., anticlockwise rotational sense in the northern hemisphere; clockwise rotational sense in the southern hemisphere) produces a sea surface Ekman transport field that is divergent, resulting in upward pumping (upwelling) of deeper waters into the surface layers of the ocean; conversely, nticyclonic wind stress curl induces convergence at the sea surface, which results in downward Ekman pumping.

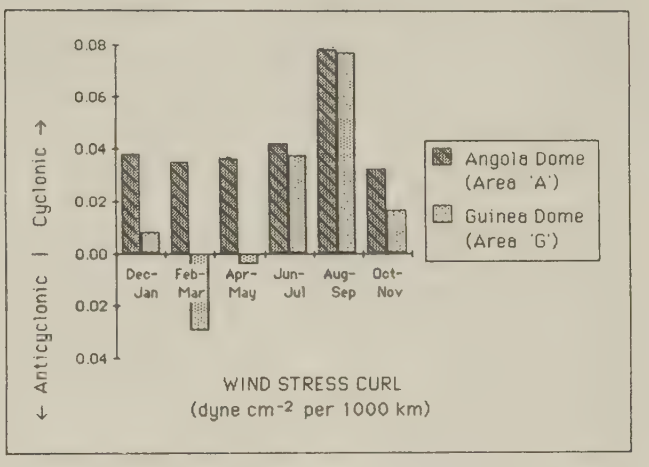


Figure 1. Characteristic seasonal variation of wind stress curl over the Guinea Dome and Angola Dome areas.

The seasonal cycles of appearance of these dome features in the upper ocean thermal structure are such that they tend to be most evident in the summer to early fall periods in the respective hemispheres. Figure 1 illustrates the manner in which the seasonal cycle of Ekman pumping in the Guinea Dome locality is indeed in phase with the appearance of upward doming of the thermal structure in summer/fall and its disappearance in late winter. However, in the case of the Angola Dome locality, cyclonic wind stress curl persists throughout the year, and in fact is at its strongest during southern hemisphere winter (Aug-Sep) when the Dome structure dissipates; thus the seasonal cycle of Ekman pumping is opposite that of the upward doming of the feature. Thus there is a discrepancy in the hypothesized pattern.

According to the comparative scientific method, this leads us to question the validity of the hypothesis that the dynamics of thermal dome features in the tropical eastern ocean are controlled primarily by local wind stress curl through the mechanism of Ekman pumping until reasons for the discrepancy can be found. Therefore, at present, it seems necessary to ascribe major effects to other mechanisms such as dynamical effects of the confluence of equatorial and eastern boundary current systems.

Studies such as this support progress toward the major PFEG goal of enhanced ability to use available large scale data sources, such as surface wind analyses from maritime weather reports, remote sensing, etc., to infer processes occurring within the habitats of fishery species. Thus, linkage mechanisms such as the hypothesis discussed above are of great interest. The comparative scientific method is thought to offer a particularly economical route toward understanding ecosystem linkages and processes, which may be very difficult to address by the more standard experimental method. (A. Bakun (408) 646-3311)

California Commercial Landings Data Computerized

Paul Sund, Oceanographer, has supervised assembly of a series of computer data files of monthly and annual landings of commercial fishes landed at California ports between 1928 and 1985. These data have been published in separate annual publications by the California Department of Fish and Game for a number of years. However, they have not previously been digitized and assembled in continuous computer-accessible time series. Under Sund's direction, programs have been written so that the data can be sorted and rearranged in various ways to facilitate time series analysis. (P. Sund (408) 646-3311)

PELAGIC FISHERY RESOURCES DIVISION

La Jolla, California

Goals for the SWFC Tuna Program Developed

Managers of the SWFC Tuna Program met on January 6, 1987, to discuss overall goals of SWFC tuna research. Attending the meeting were Center Director Izadore Barrett, Deputy Director John Carr, Honolulu Laboratory Director Richard Shomura, Pelagic Fisheries Resources Division Leader Gary Sakagawa, and Fishery Biologist George Boehlert. David Mackett was facilitator of the meeting and Wesley Parks was the rapporteur.

When responsibilities for tuna research were divided between the Southeast and the Southwest Fisheries Centers, the Southwest Fisheries Center became responsible for NMFS research on Pacific and Indian Ocean tunas. SWFC program managers, with the concurrence of the Southwest Region, developed four goals to guide tuna research at the Southwest Fisheries Center. At the January meeting the participants discussed these goals to ensure that they were clearly stated and to identify any issues related to the goals that needed to be resolved.

The first goal is to establish and operate a tuna data collection and intelligence system to provide quantitative data for NMFS research and management and to serve the needs of the U.S. tuna industry to be more competitive internationally. This goal is made up of two parts: 1. To gather more traditional fishery data on tuna fisheries of interest to the U.S. for use by NMFS researchers for stock and fishery assessment. These data would be used primarily by NMFS researchers for stock and fishery assessment. 2. To gather, analyze and distribute less traditional data on a variety of subjects related to tuna and tuna fisheries. These data would be used for a variety of purposes--to keep abreast of developments in tuna research, tuna fishery management, tuna fishing, processing and trade in tuna products--and they would be used by a variety of persons, including researchers, managers, negotiators, and industry decision makers.

Researchers and others would be able to access this central data base for all analyses including those to produce assessments. The participants agreed that data bases should be maintained for the U.S. tuna fisheries and for major non-U.S. tuna fisheries whose activities influence supplies of tuna products to U.S. consumers.

Regarding the less traditional tuna fishery information, the participants agreed that, considering the global nature of tuna fisheries and trade, it is necessary to take a broad view and that it is unrealistic to study the U.S. situation in isolation from the international situation. The participants agreed that the Center should collect and evaluate less traditional

information and make this information available for NMFS researchers, managers and negotiators, and to the U.S. tuna industry. Possible products of the intelligence system may include presentations at scientific and industry meetings and periodic bulletins.

The second goal is to produce information on the status of the stocks of fisheries and on Pacific and Indian Ocean tuna and billfishes. The participants noted that information on the tuna fisheries in the Indian Ocean was not complete, and that it would be difficult to thoroughly assess the fisheries. They agreed that effort on Indian Ocean tuna fisheries would be initially restricted to participation in assessment workshops and meetings to develop data collection and data management systems and to review information and assessments by other organizations.

The third goal is to acquire new information through research to improve substantially the conservation of the resource or the prosecution of the fishery. The participants agreed that included in this goal is research on assessment methodology and techniques. They noted that the specific activities to meet this goal would be addressed at a later tuna meeting.

The fourth goal is to provide to NMFS managers the best possible descriptions of feasible alternatives for developing U.S. strategy for fishing and managing the Pacific and Indian Ocean tuna fisheries, together with the best quantitative and qualitative estimates of the biological, environmental, economic, social and political impacts of each alternative.

The participants agreed that a first step is to produce an overview document to provide a dispassionate, analytical review of options. The members agreed that it is necessary to involve the Southwest Region and other NMFS offices in development of projects to address this goal.

In closing, the participants agreed that the four goals were clearly stated. Director Barrett closed the meeting by affirming that the goals and activities to meet those goals discussed during the meeting would guide tuna research at the Southwest Fisheries Center for many years. (W. Parks, FTS 893-7074)

STOCK ASSESSMENT AND IMPACT ANALYSIS PROGRAM

Billfish Behavior and Interaction Studied

In a cooperative research study between the National Marine Fisheries Services Tuna-Billfish Assessment Program and the California Department of Fish and Game (DFG) two striped marlin and one swordfish were successfully tracked in the fall of 1986.

These studies were designed, in part, to gain further information on the local availability of billfish in the area and determine their vulnerability to various types of commercial and recreational fishing gears. Sonic tagging and tracking of these large pelagic fish are useful in the identification of their habitat preference and will allow for more direct and efficient placement of fishing effort. Accurate knowledge of vertical and horizontal swimming patterns, of the distribution of swimming speeds, and of temperature (depth) preferences is also important in developing growth models and in determining individual energy budgets. Fishery Biologists, David Holts and Earl Weber and DFG Biologist Dennis Bedford participated in six, one-week tagging and observation trips in the Los Angeles Bight. The 60-foot sport fishing vessel, Pacific Clipper was chartered for these studies, and involved special cooperation from Jerry Thompson, Manager of the Clipper, and Ron O'Rona, Captain.

The first striped marlin was caught and tagged just after noon on September 27 only 6 miles east of Avalon, Santa Catalina Island. The vertical and horizontal movements of this fish were tracked over a 24 hour period (Figures 1 and 2). The fish traveled generally south for 37 nautical miles at an average speed of 1.5 knots, although this varied between 0.5 and 3.5 kn. It spent 63% of the time at or above 12 m, 36% of the time between 12 and 40 m, and it descended four times below 40 m.

The second marlin was tagged near the west end of San Clemente Island and tracked for 3 hours when the signal was lost due to a damaged hydrophone wire. Replacement of the defective hydrophone took approximately 30 minutes, but efforts to relocate the fish were unsuccessful. This second marlin traveled 5.5 naut. mi. in a southerly direction and stayed very near the surface during the tracking period.

These observations match closely the results of another tracking of a striped marlin conducted in 1982. This fish, also tagged and followed by Holts and Weber, traveled north for 4 hours, remained relatively inactive in the evening hours and then proceeded west for the next 17 hours. While traveling an average of 1.5 kn, the fish covered a total distance of 18 naut. mi. Nearly 86% of the tracking time was spent in the top 10 m of the water. It made only five short, early morning descents below 30 m (Figure 2). These vertical and horizontal observations of striped marlin are in sharp contrast to the movements of the swordfish.

The swordfish was tagged by a commercial harpoon fisherman half way between Avalon and Dana Point, California, in November 1986. This fish traveled in a broad clockwise circle that covered approximately 17 naut. mi. and ended 8 naut. mi. northwest of the location where it was tagged. It spent

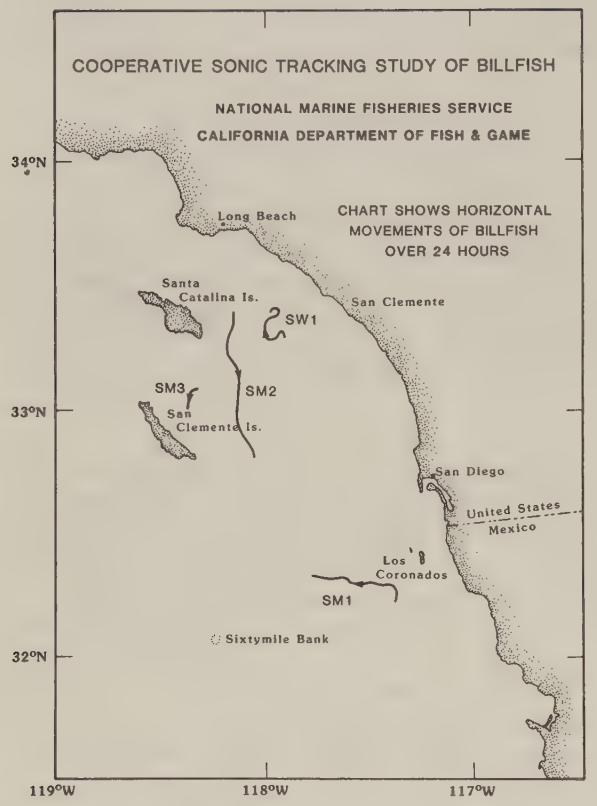


Figure 1. Horizontal movements of billfish over 24 hours.

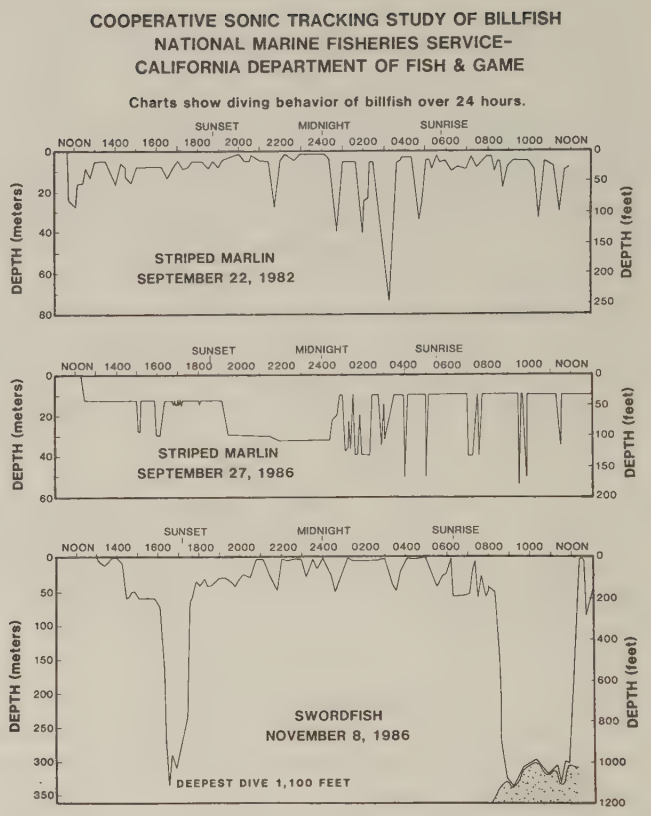


Figure 2. Diving behavior of billfish over 24 hours.

essentially all of the time below 10 m and descended below 320 m on two different occasions. During each of these descents, the swordfish went from 45 m to over 320 m in less than 15 minutes. This constitutes a change in ambient pressure from 80 psi to over 570 psi and temperature change from 14°C to 8°C. The first deep dive occurred in the late afternoon and lasted about 90 minutes. The second dive started at 0845 hrs the following morning and lasted just over 3 hours. This particular dive occurred at the "14 fathom spot," a small bank reaching to within 57 fathoms of the surface. Here its forward progress decreased and it appeared to be foraging at or very close to the bottom.

Preliminary results of this work indicate that the diel behavior of the two species of billfish differs greatly. The tracks suggest that swordfish and striped marlin spend 100% of the night hours at depths between 10 m and 50 m. The striped marlin spent 60 to 90% of their time between 10 and 30 m deep, but did not go below 60 m. Vertical excursions were more numerous at night but also occurred at irregular intervals throughout the tracking period. The swordfish spent considerable time (1.5 and 3.5 hrs) at depths over 1000 feet. Both dives were marked by abrupt descents (and ascents), which is remarkable considering the tremendous physiological stress on the fish from

changes in water temperature and pressure. The swordfish appeared to be orienting to the shallow bank where its second deep dive occurred. Marlin tended to swim faster and in a more continuous direction. The extent of their vertical excursions, for the most part, was limited to the dark period between midnight and first light. This was also the period of least horizontal movement.

Several factors in their behavior were similar to each other and to other pelagic species as well. As with several species of tuna, billfish show no reluctance to descend into the colder waters below the thermocline. In two separate dives, the swordfish spent 19% of its time in very cold water. At night, tuna generally shift their modal depth to the layers nearer the surface, whereas these billfish showed no obvious sign of this behavior. The vertical excursions of marlin tended to be greater between midnight and sunset, but swordfish showed no sign of an increase in activity during this period. Marlin covered a greater horizontal distance and maintained a steady depth over longer periods than the swordfish. Biologists have suggested some tuna species reduce the frequency of vertical excursions during periods of migration.

During this study, Holts and Weber tagged three fish in 30 boat days. This clearly indicates the difficulty of catching and successfully tagging billfish in southern California waters where they only occur seasonally and are never very abundant. The cooperative program is planned to continue through next year in order to obtain additional tracks of the movements of both species of billfish. (D. Holts and E. Weber, FTS 893-7189)

Pacific International Billfish Angler Survey Results for 1985 Reported

The National Marine Fisheries Service has conducted a billfish angler survey annually from 1969 to the present. Biologists from the NMFS use the information from the survey to determine trends in billfish fishing in the important recreational fishing areas of the Pacific and Indian oceans. The survey is conducted by Fishery Biologist James Squire, who sends out survey forms to billfish anglers. On the forms, the anglers indicate how many fish they caught for that year and how much time they spent fishing.

Squire has now estimated the catch per unit of effort (CPUE) for 1985 for striped marlin, blue marlin, black marlin, and sailfish. From the 1985 survey, he found that the total number of days reported for the Pacific and Indian oceans was 10,218, and the total number of billfish caught was 5,235 (total includes all species: blue, black, and striped marlin, sailfish, and shortbilled spearfish). He found that the CPUE for 1985 is slightly lower than the CPUE for the period 1969 to 1972. Based on the results of the survey for 1969 to 1972, the CPUE for that period was 0.55 billfish per angler day. The angler spent 1.8

days of fishing for each billfish. For 1985, the CPUE was 0.51 billfish per day and the angler spent 1.95 days fishing per billfish.

In 1985, the catch rates for striped marlin were up in all the major fishing areas for this fish (Figure 3). There was a noticeable increase in the catch rate off southern California to a record 0.32 fish per angler day; the historical CPUE for southern California has been about 0.1 fish per day or 10 days fishing per striped marlin. The CPUE for Baja California, a major recreational and commercial longline fishing area, continues to fluctuate around 0.5 billfish per angler day. Catch rates here are recovering from very low CPUE rates of 0.3 from 1977 to 1978.

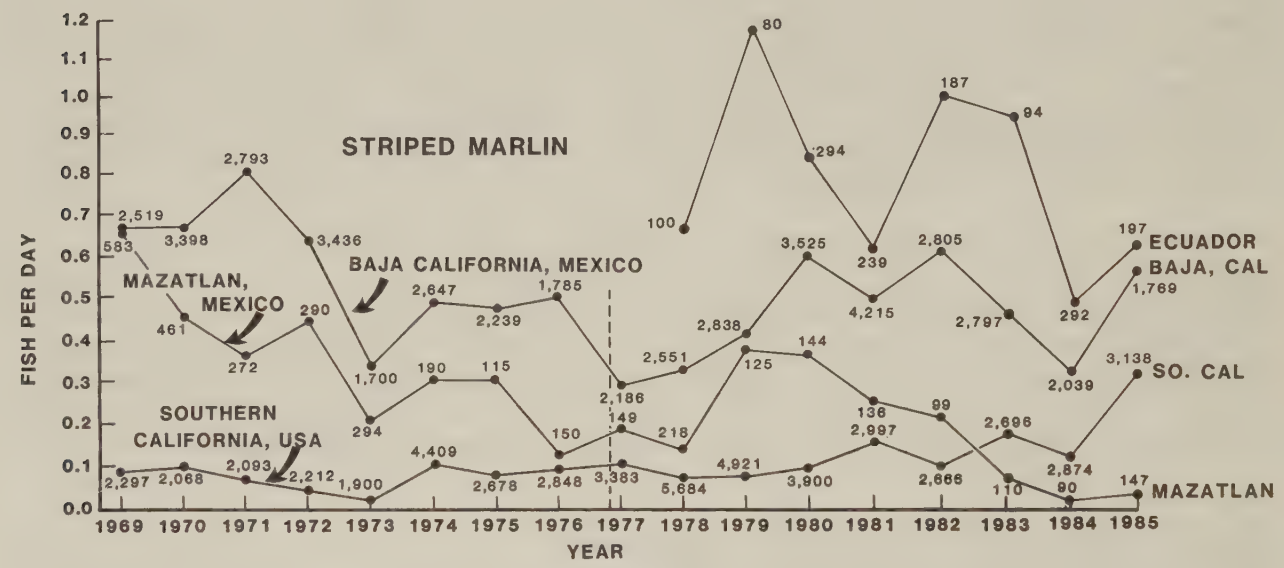


Figure 3. Catch rates for striped marlin from 1969 to 1985.

Blue marlin catch rates for the Hawaiian Islands declined considerably in 1985. Before 1985, the CPUE had been steadily increasing since 1980. It is now only slightly above the level observed in 1974 to 1976. Tahiti recorded an increase in CPUE to 0.24 billfish per day.

The major fishing area for black marlin is off Australia. The 1985 CPUE was 0.48; the CPUE had been stable in this area since 1978 at about 0.50. Before 1978, the rate fluctuated considerably for a few years.

In all major fishing areas for sailfish the CPUE rate increased, except for Costa Rica, which reported high rates. Dubai, United Arab Emirates, reported an increase in CPUE from 0.69 to 1.6 fish per angler day.

Squire will report all of this information in the Billfish Newsletter, which is now being assembled. (J. Squire, FTS 893-7072)

Fitting ELEFAN I Model to Catch-at Length Data

Fishery Biologist Pierre Kleiber and Computer Programmer Burt Baker are currently collaborating with Daniel Pauly of the International Center for Living Aquatic Resources Management in a study of the detailed behavior of the objective function used to fit Pauly's ELEFAN I model to data.

ELEFAN I is a widely used analytical model designed for conducting fishery stock assessments in situations where the only data available are catch-at-length data. The model tries to identify peaks and valleys in the length frequency data and to construct seasonally varying, von Bertalanffy growth curves that hit as many peaks and miss as many valleys as possible.

The existing method of fitting the model is an iterative search for the maximum value of the objective function. The region of the parameter space (four parameters) to search in each iteration is chosen manually. The process is cumbersome because the time to calculate the objective function at each point in the parameter space is undesirably long when using a computer such as an IBM PC. It also appears that the objective function has a complex shape with many local maxima that could cause problems in finding an optimum fit, particularly with an automatic searching routine. It is to aid in identifying such pitfalls in the use of ELEFAN I, and perhaps to help design improved fitting methods, that Kleiber and Baker are investigating the behavior of the objective function.

To get a high resolution picture of the objective function requires that they calculate its value at many closely spaced points. To do the large amount of calculation that is required, they have implemented ELEFAN I on a CRAY supercomputer. Figure 4 shows results from preliminary runs. The objective function is plotted against the two von Bertalanffy parameters, L_∞ and K, and the other two parameters, the seasonal parameters, are held fixed. This figure was generated on the CRAY in less than 8 minutes, while the machine was busy with other jobs as well. This is several hundred times as fast as an IBM PC.

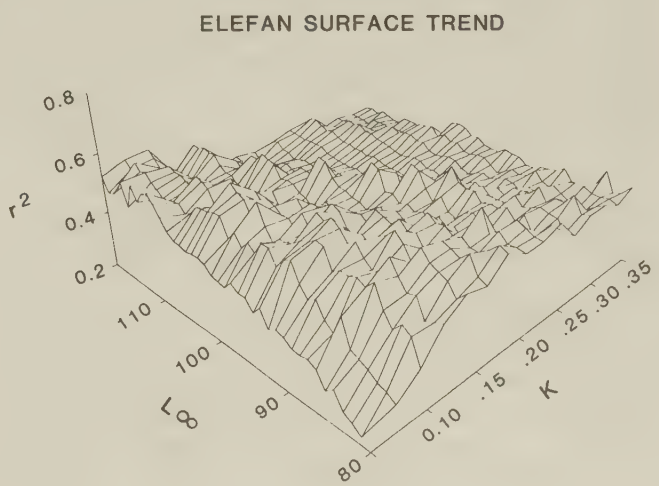


Figure 4. Plot of the objective function, r^2, against the von Bertalanffy parameters, L_∞ and K, using 1973 data on catch of Sarda chiliensis in southern California.

To help understand the behavior of the objective function, Kleiber and Baker now plan to make plots of this function against the Kleiber and Baker now plan to make plots of this function against the seasonal parameters as well as the von Bertalanffy parameters using a variety data sets. (P. Kleiber, FTS 893-7076)

MULTISPECIES DATA COLLECTION AND EVALUATION PROGRAM

North Pacific Albacore Data for 1986 Placed on Data Base

Total catch, logbook and catch length-frequency statistics for the 1986 North Pacific albacore fishery have been received through a contract with the Pacific Marine Fisheries Commission. The information was collected through a sampling program, in which samplers collect information on the fishery by interviewing captains of U.S. vessels and by collecting the logbooks maintained by the captains. Samplers collected logbook and interview information at 12 ports in California, Washington and Oregon. The data represent information from approximately 280 landings and include 18,424 albacore measured for length. Preliminary landings of albacore in 1986 were approximately 5,600 short tons, a decrease of 40% from reported landings in 1985.

Anthony Majors, Fishery Biologist, Christina Perrin, Computer Programmer, and Aaron Weinfield, Computer Technician, have placed the data on data bases and are examining the data for consistency. After this process is completed, the data will be summarized for distribution in June 1987. This is the first year that this data processing is being done on the San Diego Super Computer (CRAY XMP). (A. Coan, FTS 893-7079)

Project to Microfilm Tuna/Dolphin Observer Data Sheets Completed

NMFS observers have been going to sea aboard commercial tuna seiners fishing in the eastern tropical Pacific for many years to collect data to support research on dolphin biology and mortality reduction conducted by scientists at the Southwest Fisheries Center. The result has been a small mountain of data accumulated during the years 1971-75 and 1978-84.

Under the direction of Biological Technicians Al Jackson and Randy Rasmussen of the Multispecies Data Management Project these data have now been microfilmed. Before being microfilmed the data were subjected to rigorous intra-file and cross-file edits. The remaining year of data will be microfilmed after similar edits are completed.

In the past the data sheets have been stored on-site in leased modular office space, occupying 270 feet of shelf space. Reduced to microfilm images, these documents are now conveniently stored in two 3-foot racks. In addition to the reduction of on-site storage space requirements, the benefits of microfilm include improved document access and greater security through a system of duplicate and remotely stored original microfilms. A Minolta RP503 desktop microfilm reader-printer was purchased and installed in a reading room (B-105) adjoining the tuna/dolphin data management offices. The Minolta RP503 reads 16 mm roll film or microfiche and features a 12"x12" viewing screen, 360° motor driven image rotation, dual lens capability and dry printing on plain paper at the rate of 7.5 copies per minute. To further increase efficiency, the unit will be upgraded with automatic frame selection and computerized index. (A. Jackson, FTS 893-7048)

TIBURON LABORATORY
Tiburon, California

GROUNDFISH PHYSIOLOGICAL ECOLOGY INVESTIGATION

Yellowtail Rockfish Reproduction Monitored in Laboratory Studies

During the 1985-86 reproductive season, adult yellowtail rockfish were captured and held at the NMFS facility of the University of California Bodega Marine Laboratory. The fish were taken after the normal period of copulation and insemination, and they were monitored for gonadal development over the time when eggs would normally be fertilized, through embryonic and larval development. At completion of the spawning season, as determined by surveys of the wild yellowtail population, only 25% of the laboratory-held fish were observed to have spawned. Among the theories proposed to explain this situation were that unspawned individuals aborted their eggs, that eggs were resorbed, or that females were not inseminated. In July and December 1986, Fishery Biologist Michael Bowers began experiments designed to determine if ovaries developed in non-inseminated females, to monitor ovarian development in females which were inseminated in the wild and brought into the laboratory to spawn, and to provide the opportunity for adult yellowtail rockfish to reproduce in the laboratory. This information will be used to estimate reproductive effort and to determine adaptive reproductive capacity.

Although experiments are still underway, some preliminary results are available. For the second season, only a portion (44%) of the mature females brought into the laboratory spawned, yet all were in mid to late vitellogenesis when they were captured. Examinations of non-spawners showed that eggs were not developing and that resorption was taking place. This indicates that yellowtail rockfish have the ability to cease maturation despite being developmentally well advanced. In field-caught fish, a wide range of maturation stages have been observed throughout the spawning period. It remains to be determined whether all maturing fish in the field actually spawn. This forms a further question on the problem of potential versus real fecundity. Adult females held in isolation for over a year, and therefore not inseminated, had gonads with oocytes that progressed to the primary oogonial and early perinuclear maturation stages, but failed to initiate vitellogenesis. This further demonstrates their ability to forego reproduction and their physiological plasticity.

The mixed-sex population of laboratory-held fish will not be examined until the normal reproductive season is completed, as determined from wild fish. Nevertheless it does not appear that any of these females will develop or spawn this year.

Larvae of the fish that have successfully gone through parturition have varied in their viability. In two spawnings, all larvae died within 24 hours. No attempt is being made to rear larvae beyond yolk-sac absorption. Larval grow-out studies are planned for next season, as well as closer monitoring of embryonic development.

The combination of field and laboratory studies by the Groundfish Physiological Ecology Staff provides a basis for understanding the factors that influence rockfish reproduction. These initial observations of yellowtail rockfish in the laboratory suggest that the reproduction cycle of yellowtail rockfish is more complex than first thought, that fish are quite adaptive, and that estimates of reproductive effort of wild populations may not be accurate. (M. Bowers, FTS 556-0565)

GROUNDFISH ANALYSIS INVESTIGATION

Optimal Harvesting Policies Developed for the Widow Rockfish Fishery

Joseph Hightower and William Lenarz, Fishery Biologists, have developed a set of optimal harvesting policies for the widow rockfish (Sebastes entomelas) fishery using a microcomputer-based age-structured model. They compared traditional constant effort policies to more complex escapement policies using three criteria: the difficulty of estimating policy parameters, the average harvest obtained, and variability in harvest. Substantial computational effort was required to obtain optimal estimates for the two-parameter escapement policies, and a single run usually required 24 hours or more to complete on a microcomputer. Conservative escapement policies were similar in form and in performance to constant effort policies. Mean harvest under the least conservative escapement policy was only about 2% greater than mean harvest under a constant effort policy, yet variability in harvest increased by 49%. For stocks where density dependence is not strong, it appears that only minor improvement will be gained through the use of two-parameter escapement policies. (J. Hightower, FTS 556-0565)

Widow Rockfish Fishing Effort Studied

Traditionally, fishing effort is estimated by analyzing information from the logbooks maintained by captains of fishing boats. Fishery Biologist William Leet has been estimating effort in the widow rockfish fishery in 1983 and 1984 by analyzing data from the Pacific Fishery Information Network from those 2 years. Although trip length is not an element of the database, Leet has been analyzing the number and frequency of trips during various regulatory regimes; this information provides insight into how the fleet responds under management actions for the widow

rockfish fishery. In fact, it became apparent that the most current regulation was the single most influential factor governing fleet activity. For example, when trip limits were imposed, trip frequency increased substantially, although total landings were largely unchanged.

In both years, about 80% of the trips were made by about 30% of the vessels, although the total number of vessels that participated in the fishery was larger in 1984 than in 1983. 1984 was the first year in which a limit of trip frequency became part of the regulations. (W. Leet, FTS 556-0565)

GROUNDFISH COMMUNITIES INVESTIGATION

Predator Diet Another Effective Means to Measure Rockfish Recruitment Success

As one of several methods developed to estimate the relative success of recruitment of rockfishes (Sebastes, spp.), staff of the Groundfish Investigation have monitored the relative number of juveniles present each year in the diets of certain key predators. One of the predators is the king salmon, Oncorhynchus tshawytscha. The relative number of juvenile rockfishes in the diet of king salmon, as determined from examination of gut contents by Biological Aid Wayne Samiere, has closely matched the relative number of rockfish taken by midwater trawl during the years 1983 to 1986. A plot of average number of juvenile rockfish per trawl (on a log scale) versus average number of juvenile rockfish per stomach has a strong positive relationship (Figure 1).

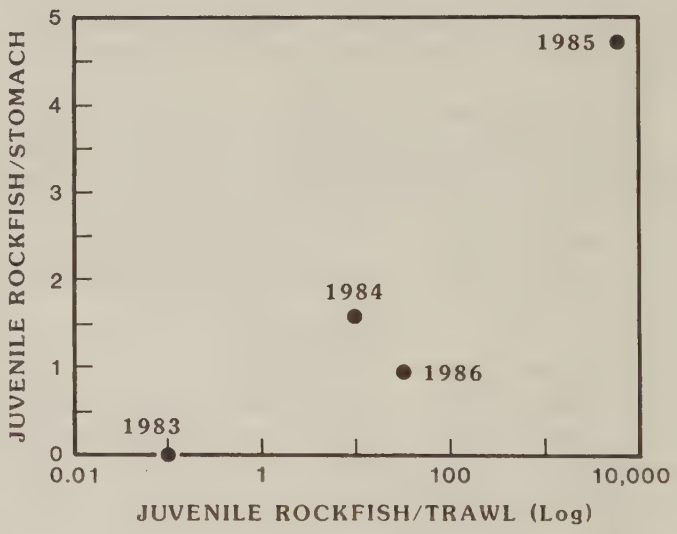


Figure 1. Number of juvenile rockfish taken in mid-water trawls vs. number of juveniles found in salmon stomachs.

In the January-February 1986 Report of Activities (as well as other past issues), Hobson reported that relative numbers of juveniles in the trawl collections from year to year matched the relative numbers counted in visual assessments made in the nearshore habitats. Thus the three methods used by the Groundfish Communities Investigation to measure the relative strength of annual recruitment in rockfishes off northern California (mid-water trawl, direct underwater counts, and this

study of gut contents of predators) continue to produce similar results. As was evident in an earlier presentation of the trawl and visual count data, recruitment was almost a complete failure during 1983, the El Nino year, but was enormously successful in 1985. Recruitment strength was intermediate between these two extremes in 1984 and 1986.

The diet analysis was based on stomach contents of specimens taken from the recreational fishery, considered the total number of juvenile rockfishes and numbers of the two most numerous species--the widow rockfish (Sebastes entomelas) and shortbelly rockfish (S. jordani). Although juveniles of other commercially important rockfishes were too few for analysis, increased sampling may produce adequate numbers of some species, e.g., bocaccio (S. paucispinis) and canary rockfish (S. pinniger). (E. Hobson, FTS 556-0565)

FISHERIES INFORMATION SYSTEMS & ADP

Correspondence Tracking System Developed

Computer Systems Analyst Frank Ralston and Computer Clerk James Payne have designed, developed, and delivered a new system for tracking progress on delegated actions, such as the preparation of correspondence for the Director's signature. The system is run on the Molecular 32X; it takes advantage of the Molecular's file sharing capability by providing online access for involved staff to a Status of Actions Table. The system is coded in SuperCalc2. Frances Tonsich, Secretary, will maintain the system. (F. Ralston, FTS 546-7062)

SWFC Hosts National Data Management Committee Meeting

On February 24 the National Data Management Committee began a 3-day work session at the La Jolla Laboratory. The committee members attending the sessions were Chairperson Ray Tillery and Hoyt Wheeland from the Office of Data and Information Systems, Washington D.C., Gene Heyerdahl from the Northeast Fisheries Center, Mary Anne Treadway from the Southeast Fisheries Center, Darrell Tidwell from the Northwest and Alaska Fisheries Center, and Dorothy Roll, Chief of ADP operations.

Ray Tillery reported that his staff has developed and is testing an ADP Procurement Tracking System, which will be implemented on the NOAA Network Service. The system allows users in the field to access the data base to view the progress of actions during the approval process cycle. Federal regulations require approval actions for the procurement of all computer equipment and services. Depending on the estimated cost of the procurement, the requests must be reviewed and approved by NMFS and NOAA or, for requests that are very expensive, by NMFS, NOAA, and DOC.

At a briefing for the La Jolla Laboratory staff, Hoyt Wheeland gave a presentation on the history and functions of the National Data Management Committee and the progress on the Information Technology 1995 project, a plan to establish a nationwide ADP support system. For the IT-95 project, questionnaires for a Requirements Initiative Analysis were sent to all Regions and Headquarters. The Requirements Initiative Analysis will be the basis for the Request for Procurement. The Request is the document for vendors to propose the configuration which will best support NMFS computing needs in the 1990s. (D. Roll, FTS 893-7057)

STATUS OF PUBLICATIONS

Published

Alvariño, Angeles. 1987. Spadella pimukatharos, a new benthic Chaetognath from Santa Catalina Island, California. Proc. Biol. Soc. Wash. 100(1):125-133.

Spadella pimukatharos is described and compared with closely related species Spadella legazpichessi, S. nana, and S. schizoptera. These species are related in part by the structure of the adhesive digital organs. The substratum apparently preferred by S. pimukatharos is a sediment rich in fragments of coralline algae.

Balazs, G. H. 1986. Fibropapillomas in Hawaiian green turtles. Mar. Turtle Newsl. 39:1-3.

Dailey, M. D., and S. Ralston. 1986. Aspects of the reproductive biology, spatial distribution, growth, and mortality of the deepwater caridean shrimp, Heterocarpus laevigatus, in Hawaii. Fish. Bull., U.S. 84:915-925.

The recent rapid development of fisheries for the Heterocarpus laevigatus in Hawaii and elsewhere in the tropical Pacific has created the need for biological information to manage the resource. This study reports on a 16-month sampling program of commercial shrimp catches in Hawaii, during which the depth of capture, carapace length (CL), sex, and reproductive condition of 7,368 H. laevigatus were determined.

The overall sex ratio of H. laevigatus was 1:1.16 in favor of females and depended on the depth sampled; there were relatively fewer females as depth increased. Seasonal variation in sex ratio was evident which may have been due to changing catchability and availability or a sex related dispersion pattern. Sex ratio also depended on size category, displaying a standard pattern with no evidence of protandry.

Females mature at 40 mm CL (64% of asymptotic length) and ovigerous individuals are found year round. However, the main reproductive season is from August-February, with over 50% of females carrying eggs from October-January. Mature shrimp may undergo a depth related seasonal migration in synchrony with breeding. Mature males and females were found deeper (700 m) during the reproductive season than not (550 m). Females apparently settle in deep water and migrate gradually to shallower water as they grow.

Seasonal length-frequency data suggest H. laevigatus is not semelparous. Separate analyses of CL-frequency distributions of male and female shrimp indicate their von Bertalanffy asymptotic sizes are 57.9 and 62.5 mm CL, respectively. Growth coefficients (K) estimated by modal progression were 0.35 and 0.25 per year for males and females, and total instantaneous mortality rates were 1.51 and 0.73 per year, respectively.

Epperly, S. P., W. H. Lenarz, L. L. Massey, and W. R. Nelson. 1986. A generalized computer program for yield per recruit analysis of a migrating population with area specific growth and mortality rates. NOAA-TM-NMFS-SEFC-180, 26 p.

Harrison, John T. 1986. The 40 MW_e OTEC plant at Kahe Point, Oahu, Hawaii: A case study of potential biological impacts. NOAA-TM-NMFS-SWFC-68, 105 p.

Hobson, E. S. 1986. Impact of changing habitats in latitudinal variations in trophic systems of teleostean fishes, pp. 33-39. In: G. W. Potts (ed.), Progress in underwater science. Rep. 19th Symp. Underwater Assoc. Sci. Res. Ltd., Vol. 11, Kent, England.

Hobson, E. S. and J. R. Chess. 1986. Relationships among fishes and their prey in a nearshore sand community off southern California. Environ. Biol. Fish. 17(3):201-226.

Trophic relationships among marine fishes in a nearshore sand environment off southern California showed that the species were distinguished by specific morphological and behavioral features adapted to capture the prey, and evade the predators, that were characteristic of that habitat. Species that foraged primarily by day included the serranid Paralabrax clathratus, the embiotocid Embiotoca jacksoni, and the labrids Halichoeres semicinctus and Semicossyphus pulcher. Primarily nocturnal foragers included the ophidiid Chilara taylori, the sciaenid Umbrina roncador, the embiotocids Cymatogaster aggregata and Hyperprosopon argenteum, and the pleuronectid Pleuronichthys coenosus. The bothid Citharichthys stigmaeus regularly fed during both day and night. The major predatory threat to these fishes came from the bothid Paralichthys californicus, which was primarily diurnal. In combination, these fishes possessed an array of behavioral and morphological feeding adaptations that closely matched the feeding opportunities present in that habitat. Not only did they consume, as a group, every species identified in samples of organisms from the environment (except the holoplankton, as discussed), they exploited these species over virtually the entire size ranges present. We infer from these circumstances that the species composition of fishes in this community was strongly influenced by the presence of specific feeding opportunities.

Leet, William S., Roger E. Green, and Daniel Ralph. 1988. Pen rearing Pacific salmon, Oncorhynchus spp., in San Francisco Bay. Mar. Fish. Rev. 48(1):24-31.

Chinook, Oncorhynchus tshawytscha, and coho, O. kisutch, salmon were pen-reared in San Francisco Bay from 1974 to 1979 at the NMFS Southwest Fisheries Center's Tiburon Laboratory, Tiburon, Calif. Environmental and experimental conditions varied from year to year and tag returns indicated an inconsistent contribution of the different pen-reared groups to the local sport fishery and ocean harvest. The best results were from chinook salmon reared in 1976. Although commercial applications of pen rearing in San Francisco Bay might succeed, we do not see the release of pen-reared fish as an effective management technique for increasing the ocean catch in California.

MacCall, Alec D. 1986. Rethinking research for fishery and ecosystem management, pp. 179-193. In: Jon G. Sutinen and Lynne Carter Hanson (eds.), Rethinking fisheries management, Chapter 11. Center for Ocean Management Studies, University of Rhode Island, Kingston, RI.

MacFarlane, R. B. and P. B. Benville. 1986. Primary and secondary stress responses of striped bass (Morone saxatilis) exposed to benzene. Mar. Biol. 92:245-254.

Murano, Masaaki, and James R. Chess. 1987. Four new mysids from Californian coastal waters. J. Crust. Biol. 7(1):182-197.

One new genus and four new species of Mysidacea collected from Californian coastal waters are described. Amathimysis trigibba, new species, is unique in having three tubercles on the carapace and is further distinguished from other species of the genus by the antennal scale, mandibular palp, fifth male pleopod, and uropod. This is the first record of the genus occurring on the Pacific coast. Acanthomysis californica, new species, is recognized as a new species by the smooth abdominal somites and the shape and armature of the telson. Acanthomysis brunnea, new species, is distinguished by the shape of the rostral plate, the slender antennal scale, the slender side lobe of the fourth male pleopod, and the shape and armature of the telson. The new genus Hippacanthomysis is distinguished from allied genera of the tribe Mysini by having an expanded and knife-shaped first segment of the exopod of the fourth male pleopod.

Myers, E. P., D. E. Hoss, W. M. Matsumoto, D. S. Peters, M. P. Seki, R. N. Uchida, J. D. Ditmars, and R. A. Paddock. 1986. The potential impact of ocean thermal energy conversion (OTEC) on fisheries. NOAA (Natl. Oceanic Atmos. Adm.) Tech. Rep. NMFS (Natl. Mar. Fish. Serv.) 40, 33 p.

The commercial development of ocean thermal energy conversion (OTEC) operations will involve some environmental perturbations for which there is no precedent experience. The pumping of very large volumes of warm surface water and cold deep water and its subsequent discharge will result in the impingement, entrainment, and redistribution of biota. Additional stresses to biota will be caused by biocide usage and temperature depressions. However, the artificial upwelling of nutrients associated with the pumping of cold deep water, and the artificial reef created by an OTEC plant may have positive effects on the local environment.

Although more detailed information is needed to assess the net effect of an OTEC operation on fisheries, certain assumptions and calculations are made supporting the conclusion that the potential risk to fisheries is not significant enough to deter the early development of OTEC. It will be necessary to monitor a commercial-scale plant in order to remove many of the remaining uncertainties.

Polovina, J. J. 1987. Assessment and management of deepwater bottom fishes in Hawaii and the Marianas. In J. J. Polovina and S. Ralston (editors), Tropical snappers and groupers: Biology and fisheries management, pp.505-532. Westview Press, Boulder and London.

Stocks of deepwater snappers, groupers, and jacks in the Mariana Archipelago are just beginning to be exploited, and it is estimated from a 5-year fishery assessment program that the annual equilibrium yield for this resource will be 109 metric tons (MT). Stocks of deepwater bottom fishes in the Hawaiian Islands have a long history of exploitation and have been fished very heavily in recent years, especially around the populated islands. Commercial landings for 1984 are estimated at 414 MT from the populated islands and 662 MT for the entire archipelago. There is some evidence that the high fishing pressure at least around the populated islands has so substantially reduced the spawning stock biomass for at least one of the major species that the recent levels of yield may not be sustainable.

The Beverton and Holt yield equation is used to evaluate the impact of fishing mortality on spawning stock biomass, and some general guidelines are proposed: When the size of entry to the fishery exceeds the size of sexual maturity, fishing mortality should not exceed twice natural mortality; and when the size of entry to the fishery is less than or equal the size of sexual maturity, fishing mortality should not exceed natural mortality. The Beverton and Holt equation is also used to simulate multispecies interactions for a developing fishery that arise when fishing mortality applied to one species impacts another. As fishing mortality increases and concurrently the size of entry to

the fishery decreases, the catches of species with higher natural mortality to growth ratios will increase relative to those with lower natural mortality to growth ratios.

Polovina, J. J., and S. Ralston. 1986. An approach to yield assessment for unexploited resources with application to the deep slope fishes of the Marianas. Fish. Bull., U.S. 84:759-770.

A comprehensive approach to estimate the maximum sustainable yield (MSY) for a tropical multispecies resource which lacks catch and effort data is presented. This yield assessment approach was used to design a fishery resource assessment survey of the Mariana Archipelago. An application of the method is presented to estimate the MSY for a multispecies bottom fish resource, based on data collected during the survey. The annual MSY for the deep slope fishes (primarily snappers and groupers) of the Mariana Archipelago is estimated to be 109 t, which for comparative purposes is equivalent to 222 kg/nmi of 200 m isobath or 0.3 t/km^2.

Polovina, J. J., and S. Ralston (editors). 1987. Tropical snappers and groupers: Biology and fisheries management. Westview Press, Boulder and London, 659 p.

Ralston, S. 1986. An intensive fishing experiment for the caridean shrimp, Heterocarpus laevigatus, at Alamagan Island in the Mariana Archipelago. Fish. Bull., U.S., 84:927-934.

During January 1984 an intensive fishing experiment for the deepwater caridean shrimp, Heterocarpus laevigatus, was conducted near Alamagan Island in the Mariana Archipelago. Twenty standard shrimp traps were set daily, producing a significant decline in the average catch rate from 3.33 to 1.82 kg/trap-night over a 16-day period. This drop was associated with a removal of 776 kg of shrimp from the study site. Resampling the area 4 months later showed that the catch rate remained depressed. Length-frequency data demonstrate that the decrease in catch per unit effort was due to a decline in the number of shrimp caught. An initial population size of 1,714 kg from 312 ha habitat is estimated, corresponding to one exploitable shrimp per 51 m^2. The estimate of catchability (0.001945 $trap\text{-}night^{-1}$) indicates that H. laevigatus may be easily overfished by trapping.

Ralston, S. 1987. Mortality rates of snappers and groupers. In J. J. Polovina and S. Ralston (editors), Tropical snappers and groupers: Biology and fisheries management, p. 375-404. Westview Press, Boulder and London.

Mortality concepts are briefly reviewed and general methods of estimating mortality rates discussed. Special attention is devoted to techniques used successfully in the study of snappers and groupers. In particular, catch curves, Z/K

ratio estimates, and the Pauly equation are shown to account for the majority of mortality estimates reported from these two taxa. A review of the snapper and grouper literature indicates that instantaneous rates of natural mortality (M) can simply be predicted with knowledge of the von Bertalanffy growth coefficient (K)--the former being roughly twice the latter. Reported agents responsible for natural deaths in these groups include predation, parasitism, cold water shock, and red tide poisoning. Examining levels of exploitation suggests that snappers have been more intensively harvested than groupers, although stocks characterized by high ratios of fishing to natural mortality are known from both families. Based on the evidence reviewed it is concluded that these species have a relatively limited productive capacity and are vulnerable to overfishing.

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Brainard, Russell and Douglas McLain. Seasonal and interannual subsurface temperature variability off Peru, 1952-1984.

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Hightower, Joseph E., and William H. Lenarz. Optimal harvesting policies for the widow rockfish fishery. For consideration for publication in the AFS Symposium Series "Mathematical analysis of fish stock dynamics: Reviews and current applications."

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Lynn, Ronald J. and James J. Simpson. California Current system --the seasonal variability of its physical characteristics. For consideration for publication in the Journal of Geophysical Research.

MacCall, Alec D. Geographical population dynamics, harvesting and environmental management. For publication in Washington Sea Grant Lectures.

Sakagawa, Gary T., Atilio L. Coan, and Norman W. Bartoo. Patterns in longline fishery data and bigeye tuna catches. For consideration for publication in Marine Fisheries Review.

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Yoklavich, M. M., and G. W. Boehlert. Daily growth increments in otoliths of juvenile black rockfish, Sebastes melanops: An evaluation of autoradiography as a new method of validation. For consideration for publication in Fishery Bulletin, U.S.

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Boggs, C. H., and S. G. Pooley (editors). 1987. Strategic planning for Hawaii's aku industry. Natl. Mar. Fish. Serv., NOAA, Honolulu, Hawaii. SWFC Admin. Rep. H-87-1, 15 p.

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Lowry, Mark S., C. W. Oliver, and J. B. Wexler. 1986. The food habits of California sea lions at San Clemente Island, California; April 1983 through September 1985. SWFC Admin. Rep. LJ-86-33, 30 p.

Lowry, Mark S., Larry J. Hansen, and Sandra D. Hawes. 1987. California sea lion and northern elephant seal pup counts and tagging at Santa Barbara Island, California, from June 1983 through July 1986. SWFC Admin. Rep. LJ-87-03, 19 p.

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